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BOLTED JOINT FATIGUE PROGRAMME. VOLUME 2. STAGE 1 APPENDICES A,--ETC(U)

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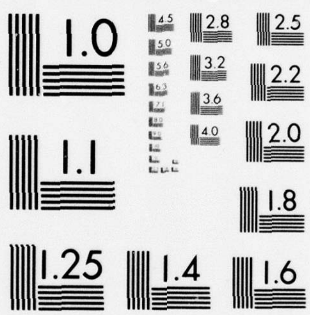
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PROCUREMENT EXECUTIVE MINISTRY OF DEFENCE

BOLTED JOINT FATIGUE PROGRAMME

VOLUME II

STAGE 1 APPENDICES A, B and C

DDC FILE COPY

R H SANDIFER

REPORT OF WORK CONDUCTED UNDER THE DIRECTION OF THE FATIGUE COMMITTEE OF THE ENGINEERING SCIENCES DATA UNIT (PREVIOUSLY THE FATIGUE COMMITTEE OF THE ROYAL AERONAUTICAL SOCIETY)
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BOLTED JOINT FATIGUE PROGRAMME.

VOLUME 2.

STAGE 1 APPENDICES A, B AND C

By

(10)

R.H. Sandifer

(Report of work conducted under the direction of the Fatigue Committee of the Engineering Sciences Data Unit (previously the Fatigue Committee of the Royal Aeronautical Society), 251-259 Regent Street, London, W1R 7AD).

SUMMARY

The programme consisted of two major parts - a photoelastic investigation into the stress distribution and resulting stress concentration factors in a family of simple bolted joints, and a correlated series of fatigue tests on bolted metal joints having the same geometrical form as the photoelastic ones using a commonly employed aluminium alloy for the plates and a steel in current use for the pins.

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BOLTED JOINT FATIGUE PROGRAMME STAGE 1

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APPENDIX A

A.1 DESCRIPTION OF THE GRIPPING ARRANGEMENTS FOR SMALL AND MEDIUM SPECIMENS

(Submitted by Cambridge University Metallurgy Department)

The two types of testing machine used had markedly different specimen holders as supplied, but both types had drawbacks which created difficulties in the alignment of specimens and their removal after test.

One machine, an Amsler Vibrophore was used to test the small specimens, and the other machine, a Losenhausen UHW6 was used to test the medium specimens.

Despite the various types of specimens in each size group, all the specimens in a particular size group were of the same thickness. Because of the large number of specimens involved and the difficulties experienced with the manufacturer's grips, it was decided to design grips specifically for the project. Previous experience had shown that self-tightening wedge grips should be avoided and that rotational alignment should be inherent in the design.

The crossheads of both machines were aligned as accurately as possible using conventional techniques.

Referring to Figures A.1, A.2 and A.3 (of this Appendix), the specimen holders consisted of a short round bar (A) with a thread at each end, the thread being cut between centres to ensure accuracy. One end of the bar screwed into a threaded component held in the machine crosshead (B), this component also having a lathe-cut thread concentric with its profile. The other end of the bar screwed into a thick rectangular plate (C) also with a lathe-cut thread. A counterbore located the bar axially.

A recess (D) on the other face of the plate accomodated a split disc (E) which had a central slot of dimensions the same as those of the specimen being tested. It should be noted that the plate was machined in such a way that when it was screwed on to the round bar, and the assembly fitted in to the machine crosshead, the centre of the recess containing the split disc was accurately located on the machine centre line, and the faces of the rectangular plate were accurately located at right angles to the machine centre line.

A specimen fitted into the slots in the split discs was thus automatically on the machine centre line.

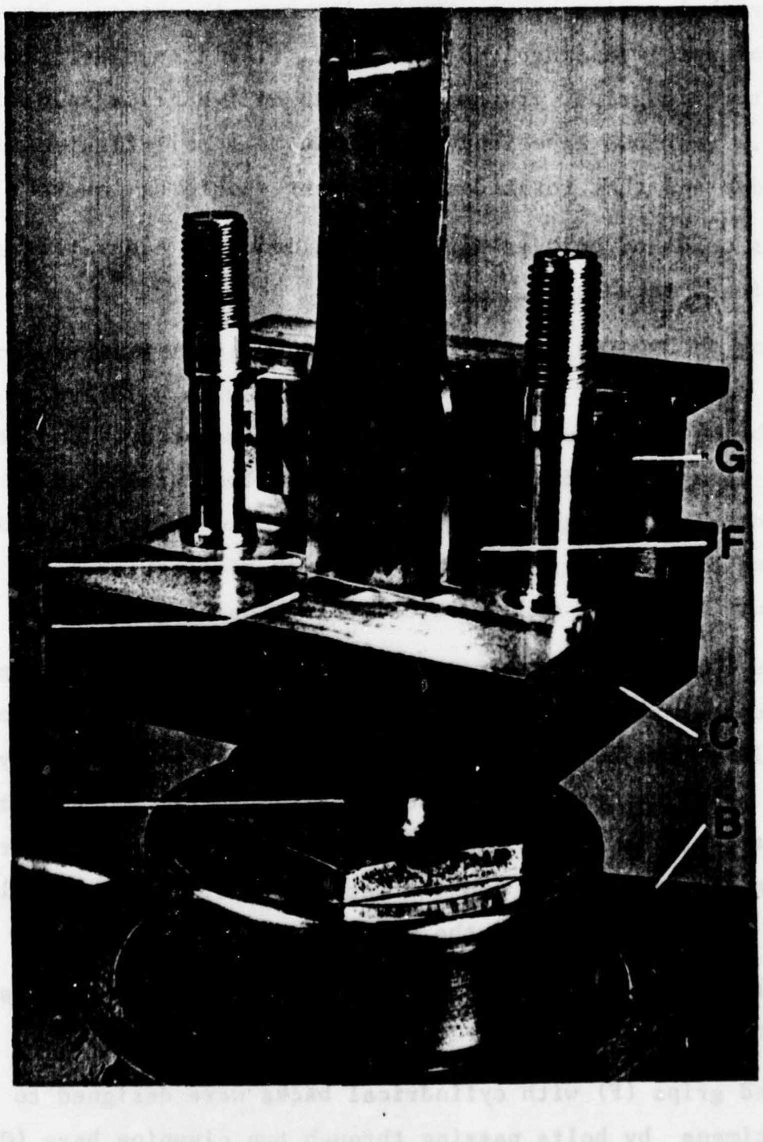
Chequered grips (F) with cylindrical backs were designed to be clamped on to the specimens by bolts passing through two clamping bars (G) which in turn were clamped to the face of the rectangular plate.

Finally, in the case of the Losenhausen machine, a wedge in the crosshead was forced against the end of the short round bar in such a way as to apply a force along the axis of the assembly, so tightening that end of the bar in the crosshead.

In the case of the Vibrophore, spigots on a threaded component prevented rotation when a nut was turned to tighten the assembly in the machine.

FIG A.1 APPENDIX A.

TESTING ARRANGEMENTS FOR MEDIUM & SMALL SPECIMENS

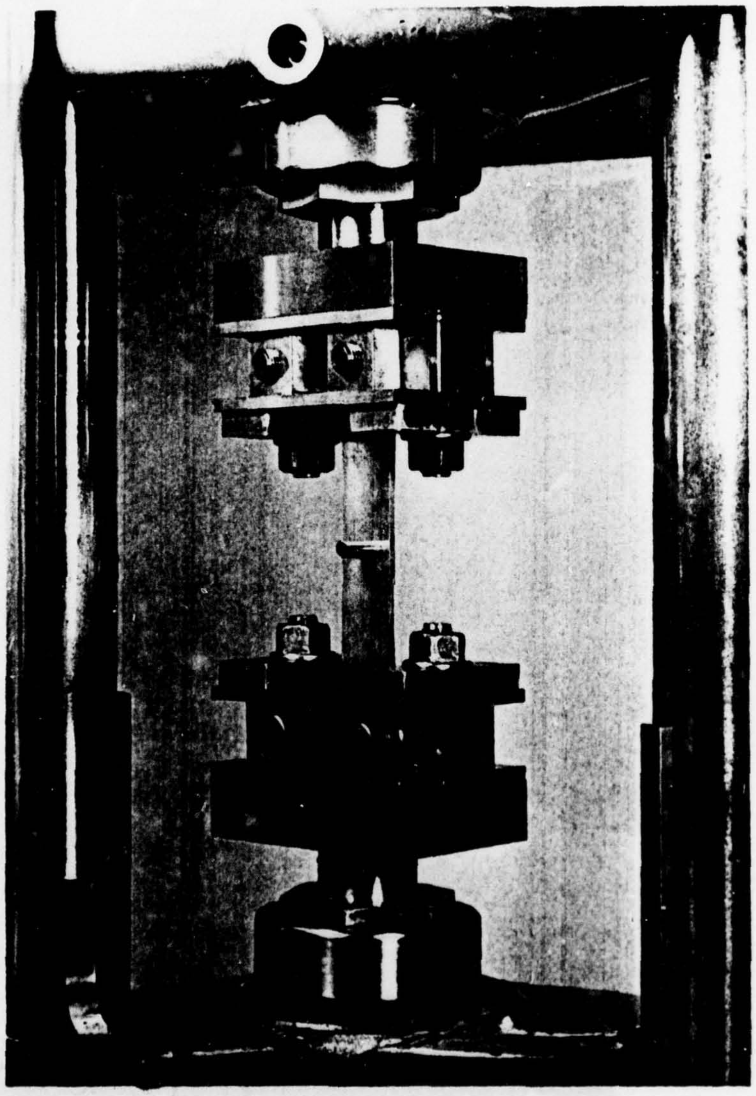


End Grips

View showing specimen in split disc itself located in recess in plate.

FIG A.2 APPENDIX A

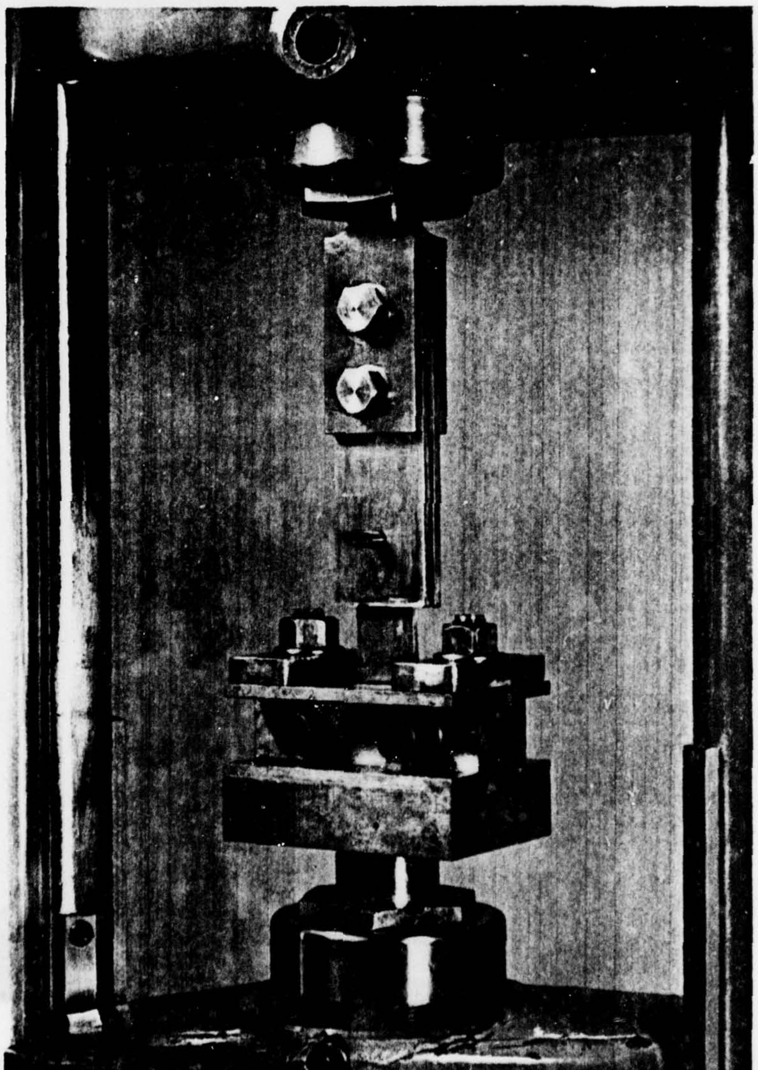
TESTING ARRANGEMENTS FOR MEDIUM & SMALL SPECIMENS



General view of assembly for testing specimens with unloaded pins

FIG A.3 APPENDIX A

TESTING ARRANGEMENTS FOR MEDIUM & SMALL SPECIMENS



General view of assembly for testing specimens with Loaded pins

APPENDIX B

SUMMARY OF RELEVANT FEATURES OF MATERIAL SPECIFICATIONS (As stated in 1956)

B.1 BRITISH STANDARD FOR AIRCRAFT MATERIAL - L71

"Aluminium - Copper - Magnesium - Silicon - Manganese
Alloy Sheets and Strips"
(Solution treated and precipitation treated).

B.1.1 Chemical Composition

Copper	-	between 3.8 and 4.8°/o
Magnesium	-	" 0.55 and 0.85°/o
Silicon	-	" 0.60 and 0.90°/o
Iron	-	not more than 1.0°/o
Manganese	-	between 0.4 and 1.2°/o
Nickel	-	not more than 0.2°/o
Zinc	-	" " " 0.2°/o
Lead	-	" " " 0.05°/o
Tin	-	" " " 0.05°/o
Titanium and/or Chromium	-	not more than 0.3°/o
Aluminium	-	the remainder

B.1.2 Condition

The material is supplied in the solution treated, straightened and subsequently precipitated condition.

B.1.3 Heat Treatment

(a) Solution treatment:- Heat at 505° ± 5°C and quench in water at a temperature not exceeding 40°C.

(b) Precipitation treatment:- Heat for the requisite period at a temperature between 160°C and 190°C.
Heating periods: 165°C from 12 to 18 hours
175°C from 9 to 12 hours
185°C from 3 to 6 hours

B.1.4 Mechanical Properties (in the condition of B.1.2)

(a) Tensile Test

0.1°/o Proof Stress	23.0 Ton/sq.in minimum
Tensile Strength	28.0 Ton/sq.in minimum
Elongation	8°/o minimum

NB The 0.1°/o proof stress applies to material thicker than 0.020 in and the elongation to material thicker than 0.104 in.

(b) Single Bend Test

(Material 0.104 in and thinner)

Angle of bend 180^{o}

Radius of former, five times nominal thickness.

B.1.5 Tolerances on Thickness

These shall be in accordance with B.S.L. 100 Table 8 for sheet and Table 10 for strip.

B.2 BRITISH STANDARD FOR AIRCRAFT MATERIAL - S 94

"55 Ton Low Alloy Steel"

(Limiting Ruling Section 2½ in)

B.2.1 Chemical Composition

Carbon	-	between 0.35 and $0.45^{o}/o$
Silicon	-	not more than $0.50^{o}/o$
Manganese	-	between 1.2 and $1.5^{o}/o$
Nickel	-	" 0.5 and $1.0^{o}/o$
Chromium	-	" 0.3 and $0.6^{o}/o$
Molybdenum	-	" 0.15 and $0.25^{o}/o$
Sulphur	-	not more than $0.050^{o}/o$
Phosphorus	-	" " " $0.050^{o}/o$

B.2.2 Process of Manufacture

Acid or basic open hearth or electric.

B.2.3 Rough Machining

See Sections 1 Clause 5.1 of B.S.S 100.

B.2.4 Condition

(a) Bars and billets for forging supplied "as rolled" or "as forged".

(b) Black bars for machining supplied hardened and tempered.

(c) Bright bars for machining supplied hardened and tempered, and subsequently cold drawn, cold rolled or ground.

(d) Forgings supplied hardened and tempered.

B.2.5 Heat Treatment

(a) Hardened in oil or water at a temperature between $830^{o}C$ and $860^{o}C$.

(b) Tempered between $550^{o}C$ and $660^{o}C$ to give the required mechanical properties.

B.2.6 Mechanical Properties

(a) Tensile Test

$0.1^{o}/o$ Proof Stress	43 Ton/sq.in minimum
Tensile Strength	between 55 and 65 Ton/sq.in.
Elongation	$18^{o}/o$ minimum

(b) Izod Test — not less than 40 ft.lb

(c) Brinell Hardness No. - between 248 and 302.

APPENDIX C

TABLES AND GRAPHS OF ALL RESULTS OF TESTS

C.1 STATIC TESTS

C.1.1 Tensile Strength

These tests were undertaken at Cambridge University to establish an average value of the tensile strength of the plate material (B.S. L71) used for the fatigue tests.

Several groups of specimens were tested in either a 50 000 lb Macklow-Smith testing machine or a 30-ton Denison machine depending upon the specimen thickness, using the appropriate load ranges. An average tensile strength for each group was obtained. The scatter of these results was small and therefore an average tensile strength for the groups as a whole was evaluated. The results were as follows:

Group 1 Specimen Type 3A, no hole - 8 off

Specimen Identification	Measured Dimensions (in)	Area (sq.in)	Failing Load (lb)	Tensile Strength (lb/sq.in)
1.1.A	0.1257 x 1.0015	0.1259	8 822	70 080
1.1.B	0.1254 x 1.0025	0.1257	8 752	69 660
1.1.C	0.1254 x 1.0010	0.1266	8 750	69 110
1.1.D	0.1251 x 1.0007	0.1252	8 762	69 980
1.1.E	0.1256 x 0.9991	0.1255	8 687	69 230
1.2.E	0.1255 x 1.0002	0.1255	8 732	69 580
1.2.B	0.1255 x 1.0004	0.1255	8 725	69 520
1.2.C	0.1260 x 1.0016	0.1262	8 750	69 330

Average Tensile Strength = 69 560 lb/sq.in
= 31.06 Ton/sq.in

Group 2 Specimen Type 2A, no hole - 5 off

Specimen Identification	Measured Dimensions (in)	Area (sq.in)	Failing Load (lb)	Tensile Strength (lb/sq.in)
23.4.A	0.157 x 1.25	0.1962	13 770	70 180
23.4.B	0.157 x 1.25	0.1962	13 850	70 600
23.4.C	0.1565 x 1.25	0.1956	13 830	70 730
23.4.D	0.157 x 1.25	0.1962	13 850	70 600
23.4.E	0.1575 x 1.25	0.1969	13 820	70 210

Average Tensile Strength = 70 425 lb/sq.in
= 31.45 Tons/sq.in

Group 3 Specimen Type 4A, no hole - 5 off

Specimen Identification	Measured Dimensions (in)	Area (sq.in)	Failing Load (lb)	Tensile Strength (lb/sq.in)
4.1.A	0.093 x 0.754	0.0713	4 895	68 640
4.1.B	0.092 x 0.752	0.0692	4 850	70 080
4.1.C	0.092 x 0.755	0.0695	4 700	67 630
4.1.D	0.092 x 0.754	0.0694	4 835	69 650
4.2.J	0.093 x 0.752	0.0699	4 917	70 340

Average Tensile Strength = 69 270 lb/sq.in
= 30.92 Tons/sq.in

Group 4 Specimen Type 2C, 15/32 in hole - 5 off

Specimen Identification	Measured Dimensions (in)	Area (sq.in)	Failing Load (lb)	Tensile Strength (lb/sq.in)
9.E	0.1565 x 0.7832	0.1226	8 736	71 250
7.D	0.1562 x 0.7812	0.1219	8 690	71 290
7.C	0.1560 x 0.7822	0.1220	8 600	70 490
7.B	0.1560 x 0.7814	0.1219	8 511	69 880
7.A	0.1562 x 0.7812	0.1219	8 646	70 920

Average Tensile Strength = 70 770 lb/sq.in
= 31.59 Tons/sq.in

Group 5 Specimen Type 2C, 5/8 in - 5 off

Specimen Identification	Measured Dimensions (in)	Area (sq.in)	Failing Load (lb)	Tensile Strength (lb/sq.in)
2.A	0.1555 x 0.625	0.0972	6 900	70 960
2.B	0.1550 x 0.624	0.0967	6 742	69 720
2.C	0.1555 x 0.624	0.0970	6 742	69 500
2.D	0.1550 x 0.625	0.0968	6 853	70 790
2.E	0.1555 x 0.626	0.0973	6 764	69 280

Average Tensile Strength = 70 050 lb/sq.in
= 31.27 Tons/sq.in

Note

A sixth group of specimens Type 4 A2 - no hole, 5 off were also tested but unfortunately the actual dimensions before testing were not measured. However, based on nominal dimensions the average Tensile Strength was 70 300 lb/sq.in = 31.38 Tons/sq.in, thus supporting the results from the other groups.

SUMMARY - TENSILE STRENGTH

In all there were three groups of specimens with no hole (18 specimens) and two groups with a hole (10 specimens). There was no significant difference between the results of the 'no hole' and 'with hole' specimens, and so the average of all measured specimens has been taken but the averages of the two separate types are also evaluated

(a) No Hole Specimens

8 off No.3 no hole, specimen 3.A, average value - 69 560 lb/sq.in
5 off No.2 no hole, specimen 2.A average value - 70 425 lb/sq.in
5 off No.4 no hole, specimen 4.A average value - 69 270 lb/sq.in

18 off no hole average value = 69 720 lb/sq.in
= 31.13 Tons/sq.in

(b) With Hole Specimens

5 off No.2 15/32 in hole, Specimen 2.C, average value - 70 770 lb/sq.in
5 off No.2 5/8 in hole, Specimen 2.C, average value - 70 050 lb/sq.in

10 off with hole average value = 70 410 lb/sq.in
= 31.45 Tons/sq.in

Hence for (a) + (b):

28 off no hole and with hole average value = 69 970 lb/sq.in
31.24 Tons/sq.in

CONCLUSION

For convenience it was decided to assume that the
Average Tensile Strength = 31.0 Ton/sq.in (69 400 lb/sq.in)
(From Minutes of Meeting at Cambridge University on 30th April 1959).

Note

This figure compares with a minimum figure of 28.0 Ton/sq.in given in the Specification B.S.L.71 - see Appendix B, paragraph B.1.4.

C.1.2 Proof Strengths

Both Cambridge University and Short Brothers and Harland carried out a few tests to determine the 0.1°/o and 0.2°/o Proof Strengths (P.S.) of the plate material.

Cambridge University - one test (Specimen No. 2A-23.11.B)

0.1°/o P.S. = 26.06 Tons/sq.in

0.2°/o P.S. = 28.13 Tons/sq.in

Average Tensile Strength (from paragraph C.1.1. group 2) = 31.45 Tons/sq.in.

Short Brothers and Harland - three tests

Specimen Type and Identification	0.1°/o P.S. tons/sq.in	0.2°/o P.S. tons/sq.in	Tensile Strength tons/sq.in	°/o Elogn. on 2 in	E x10^{-6} lb/in^2
I.C.3/4 4.3.E	28.1	28.4	31.3	10.5	10.3
1.D.1 10.4.H	28.5	28.9	31.4	10.0	9.9
1.D.1 18.10.4	28.9	29.3	31.6	12.5	10.1
Average Values	28.5	28.8	31.4	11.0	10.1

The 0.1°/o P.S. values for these tests are somewhat high relative to the 0.2°/o P.S. and to the 0.1°/o P.S. values from the Cambridge Tests, although the Short Brothers tests are consistent. The 0.2°/o P.S. values and the tensile strength values are very consistent.

CONCLUSION

In order to be consistent with the conclusion of paragraph C.1.1, and representing both laboratory tests, it will be assumed that the average proof strengths are:

0.1°/o P.S. = 27.0 = 0.87 x Tensile Strength*

0.2°/o P.S. = 28.0 = 0.90 x Tensile Strength

---

*NB This figure compares with a minimum figure of 23.0 Tons/sq.in of B.S.L71

C.2 EFFECT OF SPEED, i.e. FREQUENCY OF TESTING

This feature was investigated by Cambridge University on both types of testing machine used, namely:

6 Ton Losenhausen and 2 Ton Amsler Vibrophore

The former was used for testing the medium sized specimens and the latter for the small specimens. The actual specimens used for this investigation were not exactly of the same dimensions as that used for the main series of fatigue tests, but were nevertheless approximately so, and can therefore be regarded as representative.

For the Losenhausen Machine speed tests the specimens were approximately the same as Type 2.C 15/32 (d/D = 3/8) and for the Amsler approximately the same as Type 4.C. 9/32 (d/D = 3/8).

The speeds chosen for these tests were:

Losenhausen - 1 000 c.p.m. and 3 000 c.p.m. (Ratio 3:1)

Amsler - 3 600 c.p.m. and 7 640 c.p.m. (Ratio 2:1) approximately.

In general for each speed of testing, three or four stress levels were investigated, and about 10 specimens of nominally identical dimensions were tested at each stress level.

Only one mean stress was used, namely 25°/o Tensile strength.

RESULTS

(a) Losenhausen Machine - Speed 1 000 c.p.m.

Stress Levels ($^o/o$ Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
25	25	49 500 42 660 38 470 38 100 32 620 32 600 26 980 23 490 22 000 15 000	4.695 4.630 4.585 4.582 4.513 4.512 4.431 4.370 4.343 4.175	30 500
25	15	352 240 205 300 201 520 201 000 185 860 176 460 110 540 102 600 99 460 78 200	5.545 5.312 5.302 5.300 5.267 5.245 5.041 5.010 4 996 4.893	155 800
25	12½	751 000 535 600 478 000 470 200 289 700 179 000 156 530 130 660 130 000 129 000	5.876 5.727 5.680 5.672 5.460 5.262 5.191 5.115 5.113 5.110	262 500
25	11½	7 500 000U 3 250 000J 3 051 000U 2 246 800U 370 000 235 520 189 810	6.875U 6.511J 6.485U 6.350U 5.568 5.372 5.276	>1 160 000

U Unbroken

J Failed at Jaws

(b) Losenhausen Machine - Speed 3 000 c.p.m.

Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
25	25	32 980	4.517	23 000
		28 890	4.460	
		28 600	4.456	
		26 600	4.425	
		24 950	4.397	
		24 840	4.395	
		21 470	4.330	
		20 450	4.310	
		15 500	4.190	
		13 680	4.135	
25	15	165 200	5.216	88 900
		153 000	5.183	
		120 490	5.081	
		102 640	5.010	
		85 740	4.941	
		76 970	4.885	
		75 500	4.878	
		69 550	4.842	
		57 070	4.757	
		49 710	4.695	
25	12½	302 000	5.480	158 000
		295 600	5.470	
		230 700	5.361	
		187 800	5.272	
		167 000	5.195	
		145 300	5.162	
		129 600	5.112	
		113 400	5.054	
		96 600	4.984	
		76 000	4.880	
25	11½	6 262 000	6.796	358 000
		923 000	5.965	
		636 000	5.803	
		324 000	5.510	
		249 000	5.397	
		213 000	5.328	
		179 000	5.252	
		173 000	5.238	
		157 000	5.195	
		112 000	5.050	

(c) Amsler Machine - 3 600 c.p.m.

Stress Levels ($^o/o$ Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
25	25	40 000	4.602	28 250
		36 000	4.556	
		34 000	4.531	
		31 000	4.398	
		28 000	4.447	
		26 000	4.415	
		25 000	4.398	
		25 000	4.398	
		22 000	4.343	
		21 000	4.322	
25	15	103 000	5.015	81 500
		92 000	4.963	
		90 000	4.954	
		87 000	4.940	
		84 000	4.924	
		81 000	4.908	
		79 000	4.888	
		74 000	4.869	
		67 000	4.825	
		66 000	4.820	
25	10	1 882 000	6.275	402 000
		1 275 000	6.105	
		409 000	5.611	
		369 000	5.566	
		364 000	5.560	
		328 000	5.515	
		315 000	5.497	
		305 000	5.483	
		297 000	5.472	
		234 000	5.369	
		157 000	5.195	

(d) Amsler Machine - 7 640 c.p.m.

Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
25	25	62 000	4.791	31 700
		50 000	4.699	
		45 000	4.653	
		32 000	4.505	
		32 000	4.505	
		31 000	4.491	
		30 000	4.477	
		28 000	4.447	
		27 000	4.431	
		27 000	4.431	
		26 000	4.415	
		15 000	4.175	
25	15	120 000	5.080	84 000
		114 000	5.056	
		104 000	5.016	
		98 000	4.991	
		93 000	4.968	
		90 000	4.954	
		81 000	4.908	
		75 000	4.874	
		75 000	4.874	
		69 000	4.838	
		40 000	4.602	
25	10	1 060 000	6.025	333 000
		393 000	5.595	
		349 000	5.542	
		345 000	5.538	
		342 000	5.534	
		293 000	5.465	
		260 000	5.415	
		237 000	5.375	
		210 000	5.321	
		207 000	5.315	

SUMMARY OF GEOMETRIC MEAN VALUES

(i) Losenhausen Machine

Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Tested at 1 000 cpm	Number of Results	Tested at 3 000 c p m	Number of Results	Ratio: High Speed / Low Speed
25	25	30 500	10	23 000	10	0.82
25	15	155 800	10	88 900	10	0.57
25	12½	262 500	10	158 000	10	0.61
25	11½	>1 160 000	7	358 000	10	<0.31

(ii) Amsler Machine

Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Tested at 3 600 cpm	Number of Results	Tested at 7 640 c p m	Number of Results	Ratio: High Speed / Low Speed
25	25	28 250	10	31 700	12	1.12
25	15	81 500	10	84 000	11	1.03
25	10	402 000	11	333 000	10	0.83

In addition to the above analysis, values of standard deviation and coefficient of variation were obtained for each set of tests, using Logarithm values. The coefficient of variation for all sets lay between 1.2°/o and 5.2°/o except for those at the lowest alternating stress level on the Losenhausen Machine. These were 9.8°/o at 1 000 c.p.m. and 9.25°/o at 3 000 c.p.m.

CONCLUSIONS

1. The scatter of results is typical for jointed specimens when tested on either testing machine. In general it is not more than the equivalent of a 5°/o coefficient of variation, except at $S_m \pm S_a$ = 25°/o ± 11½°/o on the Losenhausen Machine. This exception could be due, in part, to the fact that in this particular case the machine was being operated at a moderately low load level.

2. The ratios of endurance at a given stress level for a 3:1 speed ratio are below 1.0 for the Losenhausen Machine, which is contrary to expectation. Similar figures for a 2:1 speed ratio for the Amsler are substantially nearer to 1.0, or slightly above 1.0.

3. For a given stress level and testing machine, the geometric mean endurance at one speed of testing lies reasonably well within the range of endurances for the other speed of testing.

4. Since most of the testing, for economy of time, was to be carried out at speeds near the upper level for the Amsler and at mid-level for the Losenhausen and because in general the high speed tests gave slightly lower endurances, it was concluded that the choice of testing speeds was a safe one, and not likely to lead to much error.

C.3 RESULTS OF MAIN PROGRAMME OF FATIGUE TESTS

C.3.1 General Notes

Note (1) These results are presented in two forms:

(a) Tabular (Tables C.1 to C.50) and

(b) Graphical (Figures C.1 to C.50).

For convenience a given group of results has the same reference number for both the tabular and the graphical presentation, and each is cross referenced to the other. e.g. Large specimens, Type 1.C.3/4 with 0.4^{o}/o interference fit pins, tested with the pin unloaded, are presented in Table C.10 and also in Figure C.10.

Note (2) The specimen types are illustrated in Figures 2.1 to 2.5 inclusive in the main Report.

Note (3) The levels of mean and alternating stress for fatigue cycling are given in Table 2.1 of the Main Report, and Tables 2.2, 2.3 and 2.4 give the configurations and mean stress levels actually tested. (Large, Medium and Small specimens respectively). The results of each configuration and size of specimen are presented in a separate table, thus:

	Tables C.1 to C.18 inclusive	-	Large Specimens
	Tables C.19 to C.34 "	-	Medium Specimens
and	Tables C.35 to C.50 "	-	Small Specimens

Likewise the same reference numbers cover the corresponding Figures giving the plotted results.

Note (4)

At each table heading are given:

The Specimen Type, denoting size, shape and hole diameter.

The Ratio d/D (= diameter of hole/width of specimen).

The Geometric Stress Concentration Factor K'_t (on net area).

- See Note (5) on the following page.

The Organisation responsible for the testing. Here the codes used are as follows:

C.U. - Cambridge University, Metallurgy Department.
S.B. and H - Short Brothers and Harland Ltd
T.L. - Tiltman Langley Limited and
and
NEL - National Engineering Laboratory.

The type of Testing Machine used and the speed of testing.

The Range of Loads required to insert the pins (where appropriate).

Note (5)

Regarding Geometric Stress Concentration Factors, these have been obtained from the sources indicated below, and apply to the tensile stress at the edge of the hole on a transverse diameter.

Unless stated otherwise, Stress Concentration Factors are all Geometric, and based on net cross sectional area at the hole, i.e. K_t'.

Unfilled Hole (Ref. RAeS Data Sheet 69020 Figure 2.3 (August 1969))

This figures gives K_t rather than K_t', plotted against d/D and so the readings have been converted to K_t', thus:

$$K_t' = K_t(1 - d/D)$$

d/D	=	1/4	3/8	1/2
K_t	=	3.23	3.63	4.35
$\therefore K_t'$	=	2.42	2.27	2.17

Push Fit Pin - Pin Unloaded (Ref. RAeS Data Sheet A.05.02 (April 1973))

Here K_t' for an unloaded pin $= \dfrac{2q.d}{f_{nom}}$

where q/f_{nom} is obtained from Figure 2 and 'd' from Figure 3 of that Data Sheet.

d/D	=	1/4	3/8	1/2
q/f_{nom}	=	1.79	1.28	1.0
d	=	0.685	0.9	1.08
$K'_t = \dfrac{2q.d}{f_{nom}}$	=	2.44	2.29	2.16

The S.C.F's for Unfilled Holes and for Push Fit Pin - Pin Unloaded are so near to one another that it is both convenient and advisable to use a common set of values namely:

d/D	=	1/4	3/8	1/2
K_t'	=	2.43	2.28	2.17

Push Fit Pin - Pin Loaded (Ref.RAeS Data Sheet 65004 page 2 (June 1976)) and RAeS Data Sheet A.05.02 Figure 2 (April 1973)

Here Data Sheet 65004 page 2 gives K_B instead of K_t' i.e. factor based on the pin bearing area and is converted to K_t'. Thus:

$$K_t' = K_B(D/d - 1)$$

But Data Sheet 65004 also limits the value of a/D i.e. the ratio of "radius" of lug end to width of lug to 1.0. This leads to a somewhat pessimistic value. However, the data in A.05.02 apply to a value of a/D = infinity, so that the specimens under consideration which have a value of a/D of 1.5 may be represented by taking the average of the values given by the two Data Sheets. Thus from Data Sheet 65004 page 2 for a/D = 1.0.

d/D	=	1/4	3/8	1/2
K_B	=	1.30	1.74	2.44
K_t'	=	3.90	2.90	2.44

and from A 05.02 Figure 2:

d/D	=	1/4	3/8	1/2
$K_t' = \frac{2q}{f_{nom}}$	=	3.57	2.55	2.0

Hence average values are:

d/D	=	1/4	3/8	1/2
Average K_t'	=	3.73	2.72	2.22

Loose Fit Unloaded Pin

Here the S.C.F. lies somewhere between the Push Fit Pin and an unfilled hole, but as these two values are coincident in these specimens, so also are the values of K_t' for the Loose Fit Pin - Pin Unloaded.

Loose Fit Loaded Pin

Here the S.C.F. will be somewhat greater than that for the Push Fit Pin and a nominal 10°/o increase will be assumed for these specimens, remembering that the difference in pin fit is not large (see Section 2 paragraph 2.1.2).

Thus	d/D	=	1/4	3/8	1/2
	K_t'	=	4.10	3.00	2.45

Interference Fit Pins

In Reference 4 it was found that the true Stress Concentration Factor was compounded of both the degree of interference fit and the magnitude of the applied load. Hence it is not possible to quote a single S.C.F. for a group of specimens

with the same degree of interference fit, but subject to a range of applied loads. In fact Reference 4 and Reference 5 presented the variation of S.C.F. by plotting it against the ratio of interference stress to the magnitude of applied stress at the hole.

This procedure was developed further in Reference 8 from which RAeS Data Sheet A.05.02 was eventually derived. The appropriate use of the curves in this Data Sheet will lead to the correct critical stresses in a specific case, from which the individual S.C.F. and the endurance can be estimated.

SUMMARISING, we have:

CONFIGURATION	STRESS CONCENTRATION FACTOR d/D = 1/4	3/8	1/2	REFERENCE RAeS Data Sheet
Unfilled Hole; Push Fit Pin - Pin Unloaded; Loose Fit Pin - Pin Unloaded	K'_t = 2.43	2.28	2.17	69020 Figure 2.3; A.05.02 Figures 2 and 3; See text
Push Fit Pin - Pin Loaded	K'_t = 3.73	2.72	2.22	65004 page 2; A.05.02 Figure 2
Loose Fit Pin - Pin Loaded	K'_t = 4.10	3.00	2.45	See text
Interference Fit Pin - Pin Unloaded	By using:			A.05.02 Figures 1, 2 and 3
Interference Fit Pin - Pin Loaded	By using:			A.05.02 Figures 1 and 2

Note (6)

The tables contain every result, and are grouped horizontally according to stress levels applied. In addition to actual cycles to failure, logarithm cycles to failure are given, so as to facilitate ease of any calculations which the reader may wish to carry out. These are followed by the Geometric Mean of each group of results corresponding to one stress level.

Furthermore the specimen identification number of each test sample is given. The significance of the code used is as follows:

Example:	23	2	C
	Material Sheet Number	Longitudinal Strip Number	Position of Specimen along Strip

Note 7

For the graphical presentations the following code for plotting has been used throughout:

S_m/f_t	0.50	0.40	0.25	0.20	0.15	0.125	0.10	0.05
Code	×	▲	•	⊙	■	□	▼	▽

All Geometric Mean Values are plotted thus: +

Nominally the endurance curves for each value of S_m/f_t have been drawn through the geometric mean points, but where such a procedure would have produced unreasonably shaped curves, (due to scatter) fair curves have been drawn so that the geometric mean points are equally balanced about the curves.

In some cases the amount of data available has been insufficient for a firm curve to be drawn and then a tentative curve shown thus ----- has been presented. The same form of curve indicates minor extrapolations.

In making comparisons (in the Main Report) between one group of results and another, the faired curves have been used.

CONSTANTLY, IT SHOULD BE BORNE IN MIND THAT THESE ARE MEAN CURVES AND THAT THERE IS A SIGNIFICANT SCATTER OF RESULTS ABOUT THEM. THE SCATTER OF ENDURANCE VARIES (SEE GRAPHS), BEING GENERALLY LESS AT LOW ENDURANCES (HIGH STRESS LEVELS) AND VICE-VERSA.

THE SCATTER IS NEVER NEGLIGIBLE, AND SHOULD BE ALLOWED FOR IN ESTIMATING THE SAFE LIVES OF STRUCTURAL JOINTS.

C.3.2 Comments on the Results

It should be noted that the comments in this Appendix are limited to individual features and serve only to focus attention on these results as the basis for the more general conclusions concerning the major parameters which were the chief feature of the investigation. Discussions on these wider issues are given in Section 4 of the Main Report.

These comments also serve as an elementary guide to the scope and arrangement of the investigation.

C.3.2.1 Large Specimens d/D = 1/4 Table C.1 and Figures C.1 and C.1(a) Unfilled Hole

Some of these tests were of an exploratory nature in as much as the stress levels were not all strictly as planned. Nevertheless the actual load levels were measured and used in the analysis and so the results are useful data.

The results for $S_m/f_t = 0.40$ are only plotted separately on Figure C.1(a) for clarity and the resulting mean curve transferred to Figure C.1 without the individual points.

The curves appear to be reasonable and without undue scatter. Unfortunately only one result is available for $S_m/f_t = 0.15$. In the early days of testing there was a tendency to omit tests which were likely to produce endurances in excess of 10^6 cycles, in the interests of time saving. Later the limit was set at 10^7 cycles.

It will also be noted that in addition to some specimens being unbroken at 10^7 cycles, occasionally others failed at the jaws of the testing machine or at the full section away from the hole. Failure at the jaws was overcome on the large specimens by coating the ends of the test piece with Araldite. The phenomenon of failure away from the hole is discussed collectively in the main section of the report.

Table C.2 and Figure C.2 Push Fit Pin - Pin Unloaded

These results are only at S_m/f_t of 0.50 and 0.40 and they exhibit remarkably little scatter.

Table C.3 and Figure C.3 0.4°/o Interference Fit Pin - Pin Unloaded

For this configuration there were an unusual number of failures of the specimen at the jaws of the testing machine and it was at first thought that mal-assembly was the cause, and an extra set of specimens was tested. The true cause was however the high local stresses at the jaws for the particular configuration and stress level ($S_m/f_t = 0.25$) and later specimens were coated with Araldite at the ends. (See Section 2, paragraph 2.4.2).

Table C.4 and Figure C.4 Losse Fit Pin - Pin Loaded

Although this group of tests covered a wide range of S_m/f_t only one result was obtained at a given alternating stress. Hence there are no data concerning scatter and consequently the curves have been regarded as tentative. Nevertheless the results are not far removed from those for the same configuration with push fit pins - see next group. The loose fit pins were added rather by way of exploration, and not a full investigation.

Table C.5 and Figure C.5 Push Fit Pin - Pin Loaded

Here, few data were available at high mean stresses but the results at medium and low mean stresses are consistent and free from large scatter. There was however, a moderate amount of fretting observed on the specimens tested at low values of S_m/f_t. (See Section 4 of the Main Report).

Tables C.6(a) and (b) and Figures C.6(a) and (b)
0.4°/o Interference Fit Pin - Pin Loaded

For this group there was rather a large scatter at $S_m/f_t = 0.15$. As a check some corresponding tests were carried out by the National Engineering Laboratory. The two sets, by different laboratories, but on the same type of testing machine (20 Ton Avery-Schenck) are presented in Tables C.6(a) and C.6(b) respectively and plotted on Figures of the same reference numbers. Figure C.6 gives a plot of all the points from both sources. In the circumstances the curves of Figures C.6(a) and C.6(b) are regarded as tentative and those of Figure C.6 as being more reliable.

Table C.7 and Figure C.7 0.8°/o Interference Fit - Pin Loaded

Only a few results are available and only tentative curves are presented.

C.3.2.2 Large Specimens d/D = 3/8

The preceding configurations are now repeated, but with a larger d/D ratio.

Table C.8 and Figure C.8 Unfilled Hole

Here two features are worthy of note. Firstly the effect of mean stress is negligible over the range $S_m/f_t = 0.50$ to 0.25. This feature will be found to occur on a number of other configurations and is dealt with at some length in Section 4.

Secondly there is considerable scatter of results over the full range of tests at $S_m/f_t = 0.15$. This is not altogether surprising as the stress levels are lower.

Table C.9 and Figure C.9 Push Fit Pin - Pin Unloaded

The only comment here is that the scatter at $S_m/f_t = 0.15$ is again considerable, and the appropriate curve is therefore presented as tentative.

Table C.10 and Figure C.10 0.4°/o Interference Fit Pins - Pin Unloaded

No tests were made at $S_m/f_t = 0.15$ because the endurances would clearly have fallen outside the useful range. Note that one of the specimens at a high alternating stress failed across the full section away from the hole. For general comment on this feature see Section 4 of the Main Report.

Table C.11 and Figure C.11 Push Fit Pin - Pin Loaded

No special comment.

Table C.12 and Figure C.12 0.4°/o Interference Fit Pin - Pin Loaded

Again, only one specimen was tested at $S_m/f_t = 0.15$ because of the high endurance obtained.

C.3.2.3 Large Specimens $d/D = 1/2$

This is the third group and the largest value of d/D tested.

Table C.13 and Figure C.13 and C.13(a) Unfilled Hole

These results follow the usual pattern except that the results for $S_m/f_t = 0.40$ have been plotted on Figure C.13(a) for clarity but the resulting curve is shown on Figure C.13.

Table C.14 and Figure C.14 Push Fit Pin - Pin Unloaded

No special comment.

Table C.15 and Figure C.15 $0.4^{o}/o$ Interference Fit Pin - Pin Unloaded

As would be expected these results gave high endurances and only one stress level at $S_m/f_t = 0.25$ was tested.

Table C.16 and Figure C.16 Push Fit Pin - Pin Loaded

No special comment.

Table C.17 and Figure C.17 $0.4^{o}/o$ Interference Fit Pin - Pin Loaded

Unfortunately the highest alternating stress was omitted from the tests at $S_m/f_t = 0.50$ and 0.40 but the remaining results lead to reasonable endurance curves, albeit somewhat steeper than usual. This could be due to fretting (see Section 4 paragraph 4.15.6). It is to be noted that in the set of results for $S_m/f_t = 0.25$ two specimens failed at the jaws, the cause probably being fretting at the high endurance of the samples under test.

Table C.18 and Figure C.18 $0.8^{o}/o$ Interference Fit Pin - Pin Loaded

Here only specimens at $S_m/f_t = 0.50$ were tested as the resulting endurances were comparatively high. Again there were some failures at the jaws of the specimens.

C.3.2.4 Medium Specimens $d/D = 1/4$

These follow the same configurations and loading patterns as for the large specimens, and, with the small specimens, it is hoped will throw some light on the effect of size.

Table C.19 and Figures C.19, 19(a), 19(b), 19(c) and 19(d) - Unfilled Hole

This group of tests was intended to throw some light on the possible difference between one sheet and another. In all, specimens were taken from ten different sheets, and in a number of cases, tested at the same stress levels.

The results for all sheets combined, for four values of S_m/f_t, are given on Figure C.19.

Figure C.19(a) gives separately the values for several different sheets but all at $S_m/f_t = 0.50$.

Figure C.19(b) gives similar data for $S_m/f_t = 0.40$

Figure C.19(c) " " " " $S_m/f_t = 0.25$ and

Figure C.19(d) " " " " $S_m/f_t = 0.15$.

From the data given, it is clear that the variation of endurance for a given stress level, between one sheet and another, is well within the scatter obtained when all the tests were from the same sheet.

It is a little unfortunate that for this particular set of results the difference between endurance curves for all the different mean stresses is negligible. Nevertheless, an examination of the results of tests in the same configuration, but for large specimens, and for small specimens, but with d/D = 3/8 show that where different sheets have been tested at the same stress levels, there is similar evidence. Again the evidence from C.24 (Push Fit Pin - Pin Loaded) supports this conclusion. At the other end of the scale so to speak, namely interference fit pins, there is further similar evidence. Thus it appears that there is no influence on endurance from the choice of sheet. This of course to be expected because all sheets came from the same melt. It does not necessarily follow that sheets widely different in mechanical properties and chemical composition yet still within the specification requirements, would conform to the same extent.

Table C.20 and Figure C.20 Loose Fit Pin - Pin Unloaded

Here again, there is remarkably little scatter and little difference between results of specimens tested at different levels of S_m/f_t. The same feature is observed from the results of the similar loading and configuration in the "small specimen" group. Subsequent investigation showed that for these loose fit pin specimens the protective lacquer was not completely removed from the inside of the holes before testing and could have had some influence on the results in respect of preventing fretting. On the other hand the results were slightly on the low side in terms of endurance.

Table C.21 and Figure C.21 Push Fit Pin - Pin Unloaded

Here the curve for $S_m/f_t = 0.15$ has been difficult to draw because several of the specimens were unbroken at 10^7 cycles. It has therefore been recorded as tentative.

Table C.22 and Figure C.22 0.4°/o Interference Fit Pin - Pin Unloaded

No special comment.

Table C.23 and Figure C.23 0.8°/o Interference Fit Pin - Pin Unloaded

A considerable number of these specimens were unbroken at endurances between 10^6 and 10^7 and it has not been easy to draw firm curves, but the choice has been on the conservative side so that they may be used with safety.

Table C.24 and Figures C.24, C.24(a) and C.24(b)
Push Fit Pin - Pin Loaded

In this configuration there are two groups of tests, providing some more evidence on the effect of choice of sheet. (Reference comment on C.19 above). In addition, in these groups all the specimens were taken from the same end of each sheet. The two groups (a) and (b) are plotted on separate graphs C.24(a) and C.24(b) while all the results are combined and the geometric means are plotted on Figure C.24. The scatter at a given stress level was quite small, and one is tempted to presume that this was due to all specimens being from the same end of each sheet. On the other hand an examination of the results in Tables C.2 and C.9 show that there is very little scatter between one end and another or between ends and centre. However, the results in Tables C.35 and C.37 show considerable variation between ends and centre, and even between adjacent specimens, but this variation is not consistent. Thus, position within a given sheet is not considered significant.

One other fact notable in this and other sets of results for push fit pins - pin loaded (and even in other configurations) is that there is a need for more results at low alternating stresses. This need has been met by extending the programme in this direction and the additional tests will be dealt with subsequently and separately. (Reference Stage 2 Supplementary Investigation No.9, Volume IV of this S and T memo).

Table C.25 and Figure C.25 0.4°/o Interference Fit Pin - Pin Loaded

No special comment except that an extension of results for alternating stresses below 7½°/o would be useful. (See above).

Table C.26 and Figure C.26 0.8°/o Interference Fit Pin - Pin Loaded

These results, whilst appearing reasonable on their own, are in fact very little better than those for 0.4°/o Interference Fit Pin, except at low alternating stresses.

C.3.2.5 Medium Specimens d/D = 3/8 Table C.27 and Figures C.27
Unfilled Hole

As with other groups of results in this configuration, there appears to be only a little difference between endurances at different values of mean stress (for a given alternating stress). Endurances at $S_m/f_t = 0.50$ are greater than at 0.40, but this is accidental since both are within the same scatter band.

Table C.28 and Figure C.28 Push Fit Pin - Pin Unloaded

The only comment here is that there was a little difficulty in drawing the geometric mean curve for $S_m/f_t = 0.15$ at its high endurance end, due to a majority of unbroken specimens. A guide was taken from the shapes of the other curves for this configuration.

NOTE

There are no other results for $d/D = 3/8$ since this value of d/D was added later in the programme to provide a few additional comparisons.

C.3.2.6 Medium Specimens $d/D = 1/2$ Table C.29 and Figure C.29 Unfilled Hole

See first comment under Table C.27 and Figure C.27.

Table C.30 and Figure C.30 Push Fit Pin - Pin Unloaded

Results at only two values of mean stress are available but these show normal trends.

Table C.31 and Figure C.31 $0.4^{\circ}/o$ Interference Fit Pin - Pin Unloaded

Here the endurances at $S_m/f_t = 0.25$ are so high that to draw even a tentative curve is impracticable. The curve for $S_m/f_t = 0.40$ is drawn as tentative because of a considerable number of unbroken specimens. Only one group of results at $S_m/f_t = 0.15$ is available within the useful range of endurances.

Table C.32 and Figure C.32 Push Fit Pin - Pin Loaded

No special comment.

Table C.33 and Figure C.33 $0.4^{\circ}/o$ Interference Fit Pin - Pin Loaded

The comments for the same configuration, but pin unloaded, are equally applicable to these for pin loaded (see Figure C.31).

Table C.34 and Figure C.34 $0.8^{\circ}/o$ Interference Fit Pin - Pin Loaded

As would be expected, endurances at a given stress level are generally greater than the corresponding ones at $0.4^{\circ}/o$ Interference Fit. Again it is not surprising that two samples failed at the jaws of the testing machine due to the high local stresses at high endurances. It is possible that the higher stresses due to the interference fit near, but not at, the hole were at least partly responsible for the failures away from the hole. Because of the very limited number of results for $S_m/f_t = 0.25$, no curve has been drawn for this mean stress.

C.3.2.7 Small Specimens $d/D = 1/4$ Table C.35 and Figure C.35 Unfilled Hole

In this configuration it has already been noted that there is little change of endurance for a moderate change of mean stress (over the range $S_m/f_t = 0.50$ to 0.25). In this group of results the endurance curve for $S_m/f_t = 0.50$ is actually slightly better than that for $S_m/f_t = 0.40$, but this is believed to be due to scatter and a limited number of results rather than to any fundamental differences.

Table C.36 and Figure C.36 Loose Fit Pin - Pin Unloaded

No special comment on endurances but some of these specimens were examined for evidence of fretting, see Section 4 of the Main Report.

Table C.37 and Figure C.37 Push Fit Pin - Pin Unloaded

No special comment, except to observe that most of the specimens for $S_m/f_t = 0.25$ were unbroken at 10^7 or greater endurances.

Table C.38 and Figure C.38 0.4°/o Interference Fit Pin - Pin Unloaded

A number of these specimens tested at low alternating stress levels were unbroken at endurances between 10^6 and 10^7 and the curves drawn may be somewhat conservative in this region. It was reported by the testing laboratory that "as some specimens in this batch were nearing the end of their test, they emitted a series of distinct cracking noises at intervals of 1 - 2 sec. On examining the fractured surface coarse ripples were seen which could possibly have some relation to the cracking noises that were heard". A typical specimen, 1.7.A, was photographed, (see Figures C.51 and C.52) and the photos show clearly these ripples. It is believed that the noises were associated with initial asymmetrical cracking of the specimen relative to the hole. They do not appear to have had any significant effect upon the resulting endurances.

Table C.39 and Figure C.39 0.8°/o Interference Fit Pin - Pin Unloaded

These results follow the normal pattern for such a high interference fit, i.e., high endurances, with a number of specimens still unbroken at 10^7 cycles. Again a small number of specimens at high alternating stresses failed away from the pin hole.

Table C.40 and Figures C.40 and C.40(a) and (b) Push Fit Pin - Pin Loaded

Here two groups of specimens were tested, the first group to $4B_1$ 3/16 dimensions and the second group to 4 B_2 3/16 dimensions. It should be noted that in the first group, there was some distortion around the holes due to a high pre-load, tending to make the pins approach a "loose fit". This

distortion increased under dynamic load and in some cases caused the machine to switch off prematurely. The machine was adjusted and the test continued until failure occurred. This effect was sometimes encountered on specimens tested in the Vibrophore machine, due to its high sensitivity. The final results did not appear to have suffered from this feature. In fact they were more consistent in the first group than in the second group.

In the second group the endurances for $S_m/f_t = 0.15$ were unexpectedly low and not consistent with those for other mean stresses, nor with the general pattern for other mean stresses, nor with the general pattern for other configurations. No explanation for this has been found, other than the fact that these specimens were not tested at the same time as the others in this group.

Table C.41 and Figure C.41 0.4°/o Interference Fit Pin - Pin Loaded

No special comment, except that the results at $S_m/f_t = 0.15$ are not entirely consistent with those at other values of mean stress. As in some previous configurations, these specimens were tested at a date later than the remaining ones of the group; also the loads used to insert the pins were relatively low.

Table C.42 and Figure C.42 0.8°/o Interference Fit Pin - Pin Loaded

As for the medium size specimens, this configuration results in little or no improvement over those of 0.4°/o Interference, except at low alternating stresses.

C.3.2.8 Small Specimens d/D = 3/8 Table C.43 and Figure C.43 Unfilled Hole

It may be noted here that as for the same configuration but with $d/D = 1/4$, the results for $S_m/f_t = 0.40$ give lower endurances than those for $S_m/f_t = 0.50$. The same tendency is present for $d/D = 1/2$ (see Figure C.45). Note however, that this set was tested at Tiltman Langley and those for $d/D = 1/2$ were tested at Cambridge University, and on different types of machine. However, the differences are within the scatter of results of either mean stress and therefore not significant.

Table C.44 and Figure C.44 Push Fit Pin - Pin Unloaded

Here there is some overlapping of endurance curves at various mean stress levels, and considerable scatter at high endurances making it difficult to draw firm curves.

C.3.2.9 Small Specimens d/D = 1/2 Table C.45 and Figure C.45 Unfilled Hole

See comment under Table C.43 and Figure C.43.

Table C.46 and Figure C.46 Push Fit Pin - Pin Unloaded

No special comment, the results being as expected.

Table C.47 and Figure C.47 $0.4^{o}/o$ Interference Fit Pin - Pin Unloaded

The combination of an unloaded pin with interference fit yielded many unbroken specimens, even at high or medium mean stresses. It was therefore not possible to draw curves for any mean stress other than $S_m/f_t = 0.50\ f_t$.

Table C.48 and Figure C.48 Push Fit Pin - Pin Loaded

Here the results for $S_m/f_t = 0.15$ are unexpectedly low in comparison with those for $S_m/f_t = 0.50$ to 0.25. The tests were however carried out at a different time and at a slightly higher speed. The latter should not affect the results, but from earlier experience the former may have done. The loads to insert the pins in the specimens at $S_m/f_t = 0.15$ were relatively small but not unduly so.

Table C.49 and Figure C.49 $0.4^{o}/o$ Interference Fit Pin - Pin Loaded

Once more, endurances are high with a number of unbroken specimens and only a tentative curve could be drawn for $S_m/f_t = 0.25$. The scatter for $S_m/f_t = 0.40$ at low levels of alternating stress is considerable.

Table C.50 and Figure C.50 $0.8^{o}/o$ Interference Fit Pin - Pin Loaded

The majority of specimens in this configuration were unbroken at 10^7 cycles, and it was possible only to draw a tentative curve for $S_m/f_t = 0.50$.

C.4 Miscellaneous Photographs Figures C.51 and C.52 (Reference Table C.38)

These two figures show photographs of one of the small specimens (1.7.A) which emitted a series of distinct cracking noises during the latter stages of the test. The photographs show:-

Figure C.51, both halves A and B (x 10 magnification) of the complete fracture with ripples believed to correspond with the intermittent and asymmetric stages of the fracture.

Figure C.52, part A but at x 40 magnification.

TABLE C.1 LARGE SPECIMENS UNFILLED HOLE   Reference Figures C.1 and C.1(a)

Specimen Type 1.A.1/2 $d/D = 1/4$ $K_t' = 2.43$

Tested by S.B. and H. (Reports No.8624, 8846 and 9184)

Testing Machine, 20 Ton Avery Schenck, Speed 2000 c.p.m.

Specimen Identification Number	Stress Levels (°/o Ultimate) S_m	Stress Levels (°/o Ultimate) $\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
47.1.C 35.1.A 35.1.B 29.1.B	50	22½	11 200 10 500 8 400 8 300	4.050 4.020 3.923 3.918	9 500
36.2.C 36.2.D 36.3.A 47.1.D	50	15	63 000 50 000 49 900 35 000	4.800 4.699 4.697 4.544	48 400
36.3.B 37.9.B 37.9.C	50	10	254 000 117 600 83 900	5.403 5.070 4.922	135 700
38.2.C 38.2.B 37.9.D	50	7½	10 000 000U 7 000 000J 391 000	7.000U 6.844J 5.593	>3 000 000
29.3.E 29.3.C 29.4.E	40	22½	28 000 23 000 20 900	4.446 4.361 4.319	23 800
32.2.A 32.8.D 32.5.D	40	15	75 000 71 000 67 000	4.874 4.850 4.825	70 900
40.5.B 40.5.D 40.5.C	40	11	101 000 75 000 72 500	5.004 4.875 4.860	81 900
32.1.D 40.9.D 40.9.B	40	10	10 000 000U 168 000 109 000	7.000U 5.225 5.037	>265 000
39.6.A 38.7.D 40.1.A 39.9.A	25	22½	34 300 34 200 32 200 20 600	4.535 4.533 4.507 4.313	28 800
39.9.C 40.1.B 39.9.D	25	15	109 700 78 000 77 300	5.040 4.892 4.887	87 200
40.1.C 40.1.D 40.4.A	25	12	284 000 270 000 94 000	5.542 5.430 4.972	193 300
40.8.C 41.8.B 41.7.B	25	11	10 000 000U 1 855 000F 448 000	7.000U 6.266F 5.650	>2 000 000
29.3.A 29.2.A 29.2.B	15	10	10 000 000U 382 400 332 300	7.000U 5.582 5.502	>1 083 000

U   Unbroken
F   Failure across full section away from hole
J   Failure at Jaws

TABLE C.2 LARGE SPECIMENS PUSH FIT PIN - PIN UNLOADED Reference Figure C.2

Specimen Type 1.A.1/2 d/D = 1/4 $K_t' = 2.43$

Tested by S.B. and H. (Report No.8926)

Testing Machine, 20 Ton Avery Schenck, Speed 2000 c.p.m.

Range of Loads required to insert pins, 25 to 60 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
29.1.C 29.1.D 29.5.A	50	22½	24 900 22 900 17 000	4.395 4.360 4.230	21 400
29.6.D 32.1.B 32.1.A	50	15	53 400 53 200 47 100	4.726 4.725 4.672	51 100
32.2.B 33.2.D 33.3.A	50	10	117 000 83 000 78 000	5.067 4.919 4.891	91 400
33.4.C 33.4.A 33.3.B	50	7½	152 000 144 000 132 000	5.180 5.157 5.120	143 000
33.5.A(Fr) 33.7.C 33.5.D	40	22½	28 100 24 200 19 100	4.449 4.384 4.280	23 480
33.9.D 33.8.C 33.9.B	40	15	37 100 36 100 33 200	4.570 4.556 4.521	35 400
34.9.B 33.9.C 34.8.A	40	10	113 500 103 400 91 700	5.053 5.013 4.961	102 500
35.2.A 38.2.A 38.6.A	40	7½	183 400 177 000 176 500	5.262 5.247 5.246	179 000
32.5.A 32.4.C 32.3.B	15	10	7 467 900 1 103 500 855 700	6.872 6.043 5.931	1 918 000

Note

There are no results for S_m = 25°/o Ultimate

nor for S_m = 15°/o Ultimate

except at ±10°/o Alternating Stress

(Fr) Specimen examined for fretting

TABLE C.3 LARGE SPECIMENS 0.4 °/o INTERFERENCE FIT PIN PIN UNLOADED

Reference Figure C.3

Specimen Type 1.A.1/2 d/D = 1/4 K_t' varies with loading

Tested by S.B. and H. (Report No.93)

Testing Machine, 20 Ton Schenck, Speed 2000 c.p.m.

Range of Loads required to insert pins, 1800 to 2700 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
29.2.C 33.7.A(Fr) 33.7.D	50	22½	50 900 39 900 31 500	4.705 4.600 4.498	40 000
29.5.B 29.5.C 29.2.D	50	15	108 200 93 800 82 000	5.035 4.971 4.913	94 000
29.5.D 29.6.C 29.5.E	50	10	266 000 221 900 179 000	5.423 5.345 5.252	219 600
33.1.B 33.1.A 32.1.C	50	7½	864 000 425 000 396 300	5.936 5.628 5.597	526 100
33.1.D 33.2.B 33.1.C	40	22½	106 400 92 900 82 000	5.026 4.966 4.913	93 120
33.3.C 33.2.C 33.3.D	40	15	442 200 331 600 251 600	5.645 5.520 5.400	332 400
33.9.A(Fr) 33.8.B 33.8.D	40	10	676 600 414 500 171 600	5.830 5.617 5.233	362 900
33.4.B	40	7½	10 000 000U	7.000U	>10 000 000
33.6.B 33.4.D 33.6.A 33.8.A	25	22½	1 843 000J 552 700 471 300 152 900	6.265J 5.742 5.672 5.184	>520 300
33.6.D 33.6.C 33.7.B	25	15	9 048 000J 2 560 000J 1 566 400J	6.958J 6.407J 6.194J	>3 311 000
34.3.B(Fr) 34.2.D 34.4.B 34.4.C 34.2.C	25	*15	3 462 000 2 119 900J 1 378 800 966 300J 536 900	6.540 6.325J 6.138 5.985J 5.730	>1 395 000*

U Unbroken

J Failed at Jaws

*Extra Specimens to investigate Jaw Failure

(Fr) Specimen examined for fretting

TABLE C.4 LARGE SPECIMENS LOOSE FIT PIN - PIN LOADED **Reference Figure C.4**

Specimen Type 1.B.1/2. $d/D = 1/4$ $K_t' = 4.10$

Tested by National Engineering Laboratory

Testing Machine, 20 Ton Schenck, Speed 2000 c.p.m.

Range of Loads required to insert pins, not known.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
NOT KNOWN	50	22½	5 700	3.755	5 700
	50	7½	23 700	4.374	23 700
	40	7½	21 900	4.340	21 900
	25	22½	3 200	3.505	3 200
	25	15	14 100	4.149	14 100
	25	10	29 400	4.467	29 400
	25	7½	48 500	4.685	48 500
	25	5	104 800	5.020	104 800
	25	2½	1 142 800	6.058	1 142 800
	15	7½	76 800	4.885	76 800
	15	5	231 200	5.363	231 200
	15	2½	1 842 500	6.265	1 842 500
	10	7½	111 500	5.046	111 500
	10	5	402 200	5.605	402 200
	10	2½	2 865 000	6.456	2 865 000

TABLE C.5 LARGE SPECIMENS PUSH FIT PIN - PIN LOADED Reference Figure C.5

Specimen Type 1.B.1/2 d/D = 1/4 K'_t = 3.73

Tested by S.B. and H. (Reports Nos.9184 and 9362)

Testing Machine, 20 Ton Avery Schenck, Speed 2000 c.p.m.

Range of Loads required to insert pins, 5 to 20 lb.

Specimen Identification Number	Stress Levels (o/o Ultimate) S_m	Stress Levels (o/o Ultimate) $\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
21.1.B	50	22½	4 800	3.682	4 800
21.1.F	50	10	17 200	4.235	17 200
21.4.C	40	10	18 900	4.275	18 900
24.4.E 23.6.E 23.4.G	25	15	11 900 10 800 10 800	4.075 4.033 4.033	11 100
36.1.E 36.6.E 36.7.E	25	10	26 100 25 500 22 300	4.415 4.406 4.349	24 600
21.1.E 21.4.D 21.4.E	25	7½	61 000 55 000 53 000	4.785 4.470 4.724	56 200
21.4.F(Fr) 21.4.B 21.4.A	25	5	298 000 268 000 181 000	5.475 5.428 5.257	244 000
40.2.E 40.3.E 40.6.E	20	15	23 200 17 900 15 200	4.365 4.252 4.180	18 500
37.1.E 38.2.E(Fr) 39.2.E	20	10	42 200 34 000 33 800	4.625 4.531 4.529	36 500
41.7.E 41.1.E 41.6.E 44.4.E 44.6.E	20	7½	135 200 127 000 109 800 95 000 59 000	5.130 5.104 5.040 4.978 4.770	101 000
42.6.E 42.4.E(Fr) 42.7.E	20	5	247 000 229 000 217 000	5.392 5.360 5.336	231 000
39.1.E 39.3.E 39.8.E	15	10	64 000 49 000 47 600	4.806 4.690 4.677	53 000
44.8.E 42.2.E 42.1.E 42.3.E	15	7½	138 000 91 000 79 500 79 000	5.140 4.958 4.900 4.897	94 200
44.2.E 44.3.E 43.5.E	15	5	587 100 414 500 257 400	5.768 5.618 5.410	397 000

(Fr) Specimen examined for fretting

TABLE C.6(a) LARGE SPECIMENS 0.4°/o INTERFERENCE FIT PIN **PIN LOADED**

Reference Figures

C.6(a) and C.6

Group (a)

Specimen Type 1.B.1/2 d/D = 1/4 K_t' varies with loading.

Tested by S.B. and H. (Report No.357)

Testing Machine, 20 Ton Avery Schenck, Speed 2000 c.p.m.

Range of Loads to insert pins 1600 to 2700 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
44.1.E	50	10	15 500	4.190	15 500
44.5.E	40	10	32 000	4.505	32 000
43.6.E(Fr) 43.7.E	25	15	49 800 31 700	4.697 4.500	37 500
44.7.E 43.1.E	25	10	109 200 90 900	5.039 4.958	99 600
43.9.E 43.8.E(Fr) 42.5.E	25	7½	404 000 302 000 256 000	5.606 5.480 5.408	314 900
40.8.E 40.7.E 42.8.E 41.5.E	25	5	242 900 233 500 213 600 98 600	5.385 5.367 5.329 4.993	185 900
37.9.E 36.5.E	20	15	52 700 43 300	4.722 4.636	47 700
21.1.E 37.3.E 37.5.E	20	10	137 200 57 500 26 700	5.137 4.760 4.425	59 500
39.5.E 39.4.E 21.1.D	20	7½	388 100 382 500 92 900	5.589 5.582 4.960	239 800
23.5.E 23.2.E 23.1.E	15	12½	3 328 000 853 400 145 700	6.522 5.931 5.161	745 100
20.9.A 20.7.A 20.8.A	15	10	1 928 100 1 804 000 1 037 000	6.285 6.256 6.015	1 534 000
21.10.G 20.9.G(Fr)	15	7½	12 660 000U 4 235 100	7.102U 6.627	>7 322 000

U Unbroken

(Fr) **Specimen examined for fretting**

TABLE C.6(b) LARGE SPECIMENS 0.4 ^{o}/o INTERFERENCE FIT PIN PIN LOADED

Group (b)

Reference Figures C.6(b) and C.6

Specimen Type I.B.I/2 d/D = 1/4 K'_t varies with loading

Tested by National Engineering Laboratory
Testing Machine, 20 Ton Schenck, Speed 2000 c.p.m.
Range of Loads required to insert pins, not known.

Specimen Identification Number	Stress Levels (^{o}/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
NOT KNOWN	50	22½	4 100	3.612	4 100
	50	15	35 200	4.546	35 200
	50	10	35 800	4.553	35 800
	50	7½	38 600	4.586	38 600
	40	22½	6 100	3.785	6 100
	40	15	12 600	4.100	12 600
	40	10	23 100	4.363	23 100
	40	7½	35 800	4.553	35 800
	40	5	112 100	5.050	112 100
	25	22½	2 000 7 200	3.301 3.856	4 600
	25	15	38 400	4.583	38 400
	25	10	159 900	5.203	159 900
	25	7½	174 900J 106 100	5.242J 5.025	>140 000
	25	5	185 900	5.268	185 900
	15	10	3 060 300 235 300J	6.485 5.370J	>1 647 400
	15	7½	5 419 400	6.733	5 419 400
	15	5	19 789 500	7.295	19 789 500
	10	7½	20 730 000U	7.315U	>20 730 000

U Unbroken
J Failed at Jaws of Testing Machine

TABLE C.7 LARGE SPECIMENS 0.8 ^{o}/o INTERFERENCE FIT PIN. PIN LOADED

Reference Figure C.7

Specimen I.B.I/2 d/D = 1/4 K'_t varies with loading

Tested by National Engineering Laboratory
Testing Machine, 20 Ton Avery-Schenck, Speed 2000 c.p.m.
Range of Loads to insert pins, not known.

Specimen Identification Number	Stress Levels (^{o}/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
NOT KNOWN	40	15	19 000	4.278	19 000
	40	10	34 000	4.520	34 000
	25	22½	12 000	4.079	12 000
	25	15	360 000 140 000	5.555 5.145	250 000
	25	10	380 000 320 000	5.580 5.505	350 000

TABLE C.8 LARGE SPECIMENS UNFILLED HOLE — Reference Figure C.8

Specimen Type 1.C.3/4 $d/D = 3/8$ $K_t' = 2.28$

Tested by S.B. and H. (Reports No.1031 and 1587)

Testing Machine, 20 Ton Avery Schenck, Speed 2000 c.p.m.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
5.2.B 5.3.D 5.1.E	50	22½	14 300 12 800 8 000	4.155 4.107 3.903	11 400
4.3.B 4.3.C 4.3.A	50	15	55 300 54 600 39 200	4.743 4.736 4.593	49 200
3.8.B 3.11.B 3.8.E	50	10	221 100 216 500 158 600	5.345 5.335 5.200	197 000
3.7.B 3.8.A 3.7.C	50	7½	543 800 446 300 384 100	5.745 5.649 5.584	454 000
4.5.A 4.9.C 1.1.B	40	22½	18 800 15 400 11 700	4.275 4.187 4.168	15 000
1.6.D 1.9.B 1.8.B	40	15	56 300 40 700 21 900	4.751 4.609 4.340	36 900
1.4.A 1.2.C 1.3.A	40	10	204 700 125 900 102 100	5.310 5.098 5.009	138 000
3.5.D 3.6.E 3.6.D	40	7½	9 000 000U 450 000 302 000	6.954U 5.654 5.480	>1 070 000
4.10.C 4.10.A 4.11.C	25	22½	24 100 19 000 19 000	4.381 4.278 4.278	20 600
2.6.D 2.3.A 1.9.E	25	15	51 700 49 300 44 600	4.713 4.693 4.649	48 400
1.4.E 1.5.E 1.5.D	25	10	230 200 185 800 135 000	5.362 5.267 5.130	180 000
3.5.B 2.9.A 2.13.E	25	7½	10 000 000U 535 000 285 000	7.000U 5.728 5.455	>1 150 000
5.12.D 5.14.A 6.1.A	15	12½	4 139 200U 1 142 500U 214 800	6.616U 6.059U 5.331	>1 006 000
5.12.C 5.12.A 5.12.B	15	10	10 000 000U 707 400 394 400	7.000U 5.850 5.595	>1 408 000

U Unbroken

TABLE C.9 LARGE SPECIMENS PUSH FIT PIN - PIN UNLOADED Reference Figure C.9

Specimen Type 1.C.3/4 d/D = 3/8 $K_t' = 2.28$

Tested by S.B. and H. (Reports No.1159 and 1587)

Testing Machine, 20 Ton Avery Schenck, Speed 2000 c.p.m.

Range of Loads to insert pins, 135 to 450 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
1.3.C 1.2.D 1.8.E	50	22½	25 600 25 300 17 600	4.408 4.403 4.245	22 500
2.2.D 3.5.E 2.2.C	50	15	38 500 37 000 30 000	4.585 4.568 4.477	34 950
3.10.D 3.12.B 3.9.A	50	10	136 000 106 000 94 800	5.133 5.025 4.977	111 000
4.2.A 4.1.A 4.1.C	50	7½	262 000 260 600 243 000	5.418 5.415 5.385	255 100
4.2.B 4.4.E 4.8.A	40	22½	39 000 27 100 23 200	4.591 4.433 4.364	29 050
4.9.A 4.11.D 4.11.B	40	15	89 800 71 000 41 100	4.953 4.852 4.614	63 980
6.2.E 6.6.E 4.11.E	40	10	161 000 146 900 71 500	5.206 5.165 4.853	119 000
6.9.B 7.3.A 6.9.E	40	7½	600 000 410 000 199 000	5.778 5.613 5.299	365 900
5.13.B 5.8.C 5.13.A	25	22½	48 500 46 700 46 500	4.685 4.670 4.667	47 230
6.2.D 6.2.B 6.2.A	25	15	122 000 107 000 86 000	5.085 5.029 4.933	104 000
7.4.A 7.4.D 7.4.B	25	10	400 800 301 000 258 500	5.603 5.478 5.412	314 800
4.12.B 4.12.C 5.2.A	25	7½	463 100 393 600 371 000	5.665 5.595 5.570	407 500
2.4.D 2.2.A 2.2.B	15	12½	1 611 800 295 700 273 100	6.207 5.470 5.435	506 900
1.9.D 2.1.A 2.1.D	15	10	267 800 191 700 188 900	5.428 5.282 5.276	213 200
2.4.E	15	7½	10 000 000U	7.000U	>10 000 000

U Unbroken

TABLE C.10 LARGE SPECIMENS 0.4 °/o INTERFERENCE FIT PIN **PIN UNLOADED**

Reference Figure C.10

Specimen Type 1.C.3/4 d/D = 3/8 K_t' varies with loading

Tested by S.B. and H. (Report No.1314)

Testing Machine, 20 Ton Avery Schenck, Speed 2000 c.p.m.

Range of Loads to insert pins, 2100 to 2800 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
1.4.B 1.6.E 1.6.C	50	22½	120 000 114 000 96 400	5.079 5.057 4.983	109 800
2.10.E 2.7.C 2.7.D	50	15	191 800 162 600 147 100	5.282 5.211 5.166	166 200
2.5.D 2.11.A 2.6.A	50	10	1 173 000 1 129 000 904 100	6.069 6.052 5.956	1 062 000
2.6.E 2.6.B	50	7½	8 500 000U 1 533 600	6.929U 6.185	>3 610 000
2.1.E 2.1.C 2.1.B	40	22½	326 800 302 600 259 300	5.513 5.480 5.413	294 000
2.11.D 2.11.C 2.11.B	40	15	1 118 000 500 000 344 200	6.049 5.699 5.536	577 300
3.3.A	40	10	10 000 000U	7.000U	>10 000 000
2.4.C 2.2.E 2.4.B	25	22½	773 900 600 000F 328 000	5.888 5.778F 5.516	>534 000
3.3.B 2.12.C	25	15	4 113 000 2 781 000J	6.613 6.444J	>3 390 000

U Unbroken

F Failure across full section away from hole

J Failure at Jaws

TABLE C.11 LARGE SPECIMENS PUSH FIT PIN - PIN LOADED   Reference Figure C.11

Specimen Type 1.D.3/4   d/D = 3/8 $K_t' = 2.72$
Tested by S.B. and H. (Report No.1418)
Testing Machine 20 Ton Avery Schenck, Speed 2000 c.p.m.
Range of Loads to insert pins, 45 to 225 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
14.6.F 14.1.C 14.1.G	50	22½	8 400 7 300 4 600	3.924 3.862 3.662	6 560
15.1.C 15.1.A 15.1.D	50	15	17 500 15 400 14 100	4.243 4.187 4.419	15 610
15.5.E 15.7.D 15.5.G	50	10	35 000 34 000 23 300	4.545 4.531 4.367	30 270
15.12.B 15.12.C 15.12.A	50	7½	160 900 82 600 54 000	5.178 4.916 4.732	89 520
14.4.F 14.7.C 14.9.D	40	22½	12 700 10 200 10 100	4.103 4.008 4.004	10 930
15.1.F 15.1.E 15.1.G	40	15	21 500 19 800 16 800	4.331 4.296 4.225	19 270
15.10.G 15.7.E 15.11.C	40	10	53 500 45 500 36 700	4.738 4.657 4.565	44 700
15.12.D 15.12.D 15.12.G	40	7½	95 000 88 100 79 800	4.978 4.945 4.902	87 420
14.9.E 14.13.B 14.9.G	23	22½	18 700 15 800 15 500	4.272 4.198 4.190	16 610
15.5.B 15.5.A 15.5.D	25	15	33 800 25 400 22 900	4.528 4.404 4.360	26 990
15.11.F 15.11.E 15.11.D	25	10	77 100 71 000 57 800	4.887 4.851 4.761	68 140
15.13.B 15.13.C 15.13.A	25	7½	180 100 179 500 155 900	5.256 5.254 5.191	171 400
17.13.B 17.13.D 17.13.A	15	12½	101 300 91 900 86 200	5.005 4.962 4.935	92 900
17.14.B 17.14.C 17.14.D	15	10	100 900 90 800 83 100	5.003 4.957 4.920	91 300
17.14.F 17.14.G 17.14.E	15	7½	182 100 179 000 178 500	5.260 5.252 5.250	179 900
19.8.A 17.6.A 19.8.C	15	5	1 392 500 547 800 536 400	6.134 5.737 5.730	742 500

TABLE C.12 LARGE SPECIMENS 0.4°/o INTERFERENCE FIT PIN **PIN LOADED**

Reference Figure C.12

Specimen Type 1.D.3/4 d/D = 3/8 K_t' varies with loading

Tested by S.B. and H. (Report No.1587)

Testing Machine, 20 Ton Avery Schenck, Speed 2000 c.p.m.

Range of Loads to insert pins, 1345 to 2240 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
17.6.C 17.6.D 17.6.B	50	22½	15 600 13 800 10 500	4.193 4.140 4.020	13 120
17.7.F 17.7.G 17.7.E	50	15	30 800 25 100 19 800	4.489 4.400 4.296	24 830
17.9.D 17.9.G 17.9.E	50	10	43 500 43 500 30 600	4.638 4.638 4.485	38 690
17.11.B 17.10.G 17.11.A	50	7½	94 400 84 000 45 600	4.975 4.923 4.659	71 250
17.6.E 17.6.F 17.6.G	40	22½	27 100 20 500 19 200	4.432 4.312 4.283	20 020
17.12.C 17.8.C 17.8.A 17.8.B	40	15	35 000 30 100 28 000 19 300	4.545 4.479 4.446 4.285	27 480
17.10.C 17.10.B 17.10.A	40	10	81 300 78 200 66 100	4.910 4.893 4.820	74 900
17.11.F 17.11.E 17.11.C	40	7½	118 200 104 500 88 100	5.071 5.020 4.945	102 800
17.7.C 17.7.B 17.7.D	25	22½	88 600 55 700 36 000	4.947 4.746 4.556	56 220
17.9.C 17.9.D 17.9.A	25	15	196 400 99 300 61 900	5.292 4.996 4.791	106 400
17.10.D 17.10.E 17.10.F	25	10	1 060 000 472 000 392 800	6.025 5.520 5.595	581 500
17.12.B 11.11.G	25	7½	10 000 000U 1 862 800	7.000U 6.270	>4 316 000
19.8.D	25	12½	4 000 000U	6.602U	>4 000 000

U Unbroken

TABLE C.13 LARGE SPECIMENS UNFILLED HOLE

Reference Figures C.13 and C.13(a)

Specimen Type 1.C.1 $d/D = 1/2$ $K_t' = 2.17$

Tested by S.B. and H. (Reports No.9519 and 1587)

Testing Machine, 20 Ton Avery Schenck, Speed 2000 c.p.m.

Specimen Identification Number	Stress Levels (°/o Ultimate) S_m	Stress Levels (°/o Ultimate) $\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
10.4.B 8.13.E 14.2.E 10.4.D 14.3.A	50	22½	22 000 18 500 17 600 16 000 13 000	4.342 4.266 4.245 4.203 4.113	17 620
8.1.A 8.1.D 8.13.A	50	15	47 800 44 500 33 500	4.680 4.649 4.525	41 750
8.13.B 8.13.C 8.13.D	50	10	136 000 130 500 127 400	5.133 5.115 5.105	131 000
10.8.D 10.9.C 10.10.D	50	7½	319 000 255 800 254 300	5.502 5.406 5.386	274 400
12.6.C 12.5.C 12.8.C	40	22½	17 600 17 300 16 700	4.245 4.238 4.222	17 300
12.1.E 12.5.B 12.1.D	40	15	52 300 51 900 48 600	4.719 4.715 4.686	50 900
11.1.D 11.1.E 11.2.A	40	10	297 100 120 200 118 300	5.473 5.080 5.071	161 700
11.1.A 14.3.D 11.1.B 11.1.C	40	7½	269 600 267 200 251 800 207 800	5.430 5.425 5.401 5.318	247 900
12.9.A 12.9.B 12.9.C	25	22½	29 400 24 000 19 200	4.468 4.380 4.283	23 960
12.9.D 12.9.E 12.10.B	25	15	74 800 57 500 53 300	4.873 4.760 4.726	61 200
13.1.B 12.10.D 13.1.C	25	10	199 900 158 200 147 100	5.299 5.200 5.166	166 500
13.14.C 13.10.C 13.14.A	25	7½	10 144 600U 299 400 266 700	7.005U 5.475 5.426	>924 000
11.4.A 11.5.B 11.4.E	15	12½	990 100 726 200 168 200	5.996 5.860 5.225	494 400
11.5.D 11.5.E	15	10	10 000 000U 3 000 000U	7.000U 6.477U	>5 476 000

U Unbroken

TABLE C.14 LARGE SPECIMENS PUSH FIT PIN - PIN UNLOADED Reference Figure C.14

Specimen Type 1.C.1 $d/D = 1/2$ $K'_t = 2.17$

Tested by S.B. and H. (Reports No.9727)

Testing Machine, 20 Ton Avery Schenck, Speed 2000 c.p.m.

Loads required to insert pins, approximately 20 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
8.1.B 8.3.D 8.2.E 8.2.C	50	22½	35 300 27 400 26 600 18 600	4.547 4.436 4.425 4.270	26 300
8.6.E 8.3.E 8.5.B	50	15	46 000 45 100 36 000	4.663 4.655 4.656	42 100
8.9.A 8.7.C 8.7.A	50	10	97 700 89 700 79 600	4.990 4.953 4.900	88 700
8.10.D 8.10.C 8.10.A	50	7½	217 200 171 700 153 600	5.335 5.234 5.185	178 700
10.7.B 10.10.E 8.14.D	40	22½	33 600 32 700 23 500	4.526 4.515 4.370	29 600
8.14.B 8.14.C 8.12.E	40	15	62 900 61 000 46 500	4.797 4.785 4.667	56 300
8.12.D 8.12.C 8.12.B	40	10	116 700 107 900 66 200	5.067 5.032 4.820	94 100
8.11.D 8.11.B 8.12.A	40	7½	317 000 256 400 250 000	5.500 5.407 5.398	273 000
10.14.B 10.12.E 10.14.C	25	22½	53 400 51 500 43 000	4.727 4.711 4.633	49 100
10.14.D 10.14.E 11.2.C	25	15	94 100 92 700 68 400	4.972 4.966 4.834	84 100
11.2.E 11.2.D 11.3.E	25	10	178 300 146 100 129 000	5.250 5.164 5.110	149 700
11.4.C 11.4.D 11.4.B	25	7½	310 300 269 200 264 500	5.490 5.430 5.420	280 600

TABLE C.15 LARGE SPECIMENS 0.4°/o INTERFERENCE FIT PIN PIN UNLOADED

Reference Figure C.15

Specimen Type 1.C.1. $d/D = 1/2$ K_t' varies with loading

Tested by S.B. and H. (Report No.9864)

Testing Machine, 20 Ton Avery Schenck, Speed 2000 c.p.m.

Range of Loads required to insert pins - 2500 to 6400 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
8.2.A 8.2.D 8.2.B	50	22½	277 700 242 300 131 300	5.443 5.383 5.117	206 700
8.3.B 8.3.C 8.3.A	50	15	403 100 374 400 290 800	5.605 5.573 5.463	352 900
8.4.A 8.4.C 8.4.B	50	10	2 056 500 1 426 100 860 800	6.312 6.153 5.953	1 362 000
8.4.E 8.4.D	50	7½	10 108 400U 2 004 000	7.004U 6.301	>4 500 000
8.6.C 8.6.D	40	30	231 700 123 400	5.363 5.090	169 100
8.5.C 8.6.B 8.5.A	40	22½	414 500 391 800 276 500	5.616 5.592 5.440	355 400
8.7.D 8.7.B	40	17½	1 626 100 1 264 600	6.211 6.102	1 432 000
8.6.A 8.5.D	40	15	10 000 150U 3 174 800	7.000U 6.501	>5 500 000
8.8.B 8.8.A 8.7.B	25	22½	2 102 000J 1 764 000J 1 705 000J	6.322J 6.246J 6.232J	>1 850 000

U Unbroken

J Failed at Jaws

TABLE C.16 LARGE SPECIMENS PUSH FIT PIN - PIN LOADED Reference Figure C.16

Specimen Type L.D.I. d/D = 1/2 $K_t' = 2.22$

Tested by S.B. and H. (Report No.9727)

Testing Machine, 20 Ton Avery Schenck, Speed 2000 c.p.m.

Loads required to insert pins, approximately 20 lb.

Specimen Identification Number	Stress Levels (o/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
15.2.B 15.2.D 15.2.C	50	22½	14 900 10 800 10 000	4.172 4.033 4.000	11 700
15.2.E 15.2.G 15.2.F	50	15	26 960 20 200 18 400	4.430 4.305 4.265	21 500
15.3.A 15.3.C 15.3.B	50	10	50 400 40 900 37 300	4.702 4.611 4.571	42 500
15.3.F 15.3.E 15.3.D	50	7½	131 200 127 900 87 400	5.117 5.106 4.941	113 600
17.1.C 17.1.D 17.1.E	40	22½	14 600 12 800 12 800	4.165 4.107 4.107	13 400
17.1.A 15.6.G 15.6.F	40	15	21 100 20 500 15 600	4.323 4.311 4.193	18 900
15.6.C 15.6.D 15.6.E	40	10	48 500 48 500 38 600	4.685 4.685 4.586	44 900
15.6.A 15.3.G 15.6.B	40	7½	146 200 119 500 113 200	5.165 5.075 5.052	125 500
17.1.G 17.2.A 17.2.B	25	22½	21 600 17 000 14 600	4.334 4.230 4.165	17 500
17.2.E 17.2.D 17.2.F	25	15	47 600 40 800 35 600	4.677 4.610 4.564	41 000
17.2.G 17.3.B 17.3.C	25	10	91 300 74 100 73 400	4.960 4.870 4.865	79 200
17.3.D 17.3.F 17.3.E	25	7½	337 700 225 600 146 900	5.527 5.353 5.166	223 600

TABLE C.17 LARGE SPECIMENS 0.4 $^{o}/o$ INTERFERENCE FIT PIN **PIN LOADED**

Reference Figure C.17

Specimen Type 1.D.1. d/D = 1/2 K_t' varies with loading

Tested by S.B. and H. (Reports No.357 and 741)

Testing Machine, 20 Ton Avery Schenck, Speed 2000 c.p.m.

Range of Loads required to insert pins, 2000 to 5000 lb.

Specimen Identification Number	Stress Levels ($^{o}/o$ Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
16.3.C 16.3.A 16.3.E	50	15	94 800 81 800 40 200	4.976 4.912 4.605	67 800
18.7.D 18.7.E	50	10	98 800 61 300	4.994 4.788	77 860
18.7.F 18.14.B	50	7½	102 800 91 900	5.011 4.963	97 180
16.4.B 16.4.A 16.3.G	40	15	1 383 600 793 700 336 000	6.140 5.899 5.526	716 000
16.5.C 16.5.D 16.12.A	40	10	2 583 000 1 310 000 1 198 000	6.413 6.166 6.078	1 595 000
16.12.D 16.14.A 16.12.B	40	7½	10 000 000U 1 172 700 1 121 000	7.000U 6.068 6.050	>2 360 000
17.4.D 17.4.E 18.5.G	25	22½	2 691 000J 1 278 000 781 000	6.430J 6.106 5.892	>1 390 000
18.1.A 18.7.C 18.7.B	25	15	6 796 500J 6 598 200 3 849 700	6.831J 6.820 6.585	>5 568 000

U Unbroken J Failed at Jaws

TABLE C.18 LARGE SPECIMENS 0.8 $^{o}/o$ INTERFERENCE FIT PIN PIN LOADED

Reference Figure C.18

Specimen Type 1.D.1. d/D = 1/2 K_t' varies with loading

Tested by S.B. and H. (Report No.882)

Testing Machine, 20 Ton Avery-Schenck, Speed 2000 c.p.m.

Range of Loads required to insert pins, 3700 to 5600 lb.

Specimen Identification Number	Stress Levels ($^{o}/o$ Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
17.4.A(Fr) 16.14.B	50	22½	1 558 500 1 379 500J	6.192 6.138J	>1 467 000
16.11.G 16.3.D	50	15	5 523 000J 2 125 900	6.742J 6.327	>3 426 000
16.12.G 16.2.G 16.12.C(Fr)	50	10	10 000 000U 10 000 000U 2 791 000	7.000U 7.000U 6.445	>6 536 000

U Unbroken
J Failure at Jaws
(Fr) Specimen examined for fretting

TABLE C.19 MEDIUM SPECIMENS UNFILLED HOLE

Reference Figure C.19, C.19(a), (b), (c) and (d)

Specimen Type 2.A.5/16 $d/D = 1/4$ $K_t' = 2.43$
Tested by C.U.
Testing Machine, 6 Ton Losenhausen Speeds - see below

Note The results in this particular table (2 pages) provide some evidence of comparison between different sheets and also a little evidence of the effect of speed of testing.

Specimen Identification Number	Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
(a) Sheet 22 Speed of Testing - 3000 c.p.m.					
22.13.C 22.13.E 23.13.B	50	22½	30 100 21 610 20 100	4.479 4.334 4.302	23 500
22.15.B 22.15.D 22.15.C	50	15	94 780 82 450 69 410	4.977 4.915 4.840	81 500
22.16.C 22.16.B 22.16.D	50	10	233 130 200 830 177 000	5.368 5.302 5.248	203 000
22.16.E	50	7½	281 100	5.448	281 100
(b) Sheet 23 Speed of Testing - 3000 c.p.m.					
23.16.B	50	7½	399 670	5.600	399 670
(c) Sheet 24 Speed of Testing - 3000 c.p.m.					
24.3.C	50	7½	377 380	5.576	377 380
24.16.D 24.16.E 24.8.A 24.10.C	40	22½	26 880 26 800 20 700 15 670	4.429 4.428 4.315 4.195	22 000
(d) Sheet 25 Speed of Testing - 3000 c.p.m.					
25.3.B 25.4.D 25.3.D	40	15	55 810 48 910 48 420	4.745 4.690 4.685	51 000
25.5.B 25.4.E 25.5.A	40	10	208 590 102 830 79 660	5.320 5.012 4.901	119 350
25.6.D 25.6.E 25.8.E	40	7½	7 568 560 811 030 314 450	6.878 5.909 5.497	1 240 000
25.9.C	25	22½	31 880	4.503	31 880
(e) Sheet 26 Speed of Testing - 3000 c.p.m. for S_m = 25°/o and 1500 c.p.m. for S_m = 15°/o					
26.1.E 26.1.D	25	22½	29 460 25 810	4.468 4.413	27 635
26.9.B 26.13.A 26.13.B	25	15	96 550 83 750 67 180	4.985 4.912 4.827	81 700
26.13.C 26.18.E	25	10	10 128 340U 10 000 780U	7.005U 7.000U	>10 064 560
26.14.D 26.14.B	15	12½	219 850 175 990	5.340 5.245	196 200
26.16.E 26.17.A	15	10	437 100 222 680	5.640 5.349	312 000

U Unbroken

TABLE C.19 MEDIUM SPECIMENS UNFILLED HOLE **Reference Figure C.19**
(continued)

Specimen Identification Number	Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
(f) Sheet 27 Speed of Testing - 3000 c.p.m. for all except 50 ±22½ and 50 ±15 which were 2000 c.p.m.					
27.1.E 27.1.C 27.1.D	50	22½	28 910 26 210 20 640	4.460 4.417 4.315	25 000
27.1.A 27.2.A 27.1.B	50	15	58 090 45 950 41 910	4.765 4.661 4.621	48 200
27.2.B 27.2.C 27.2.D	50	10	445 150 312 850 190 120	5.648 5.495 5.279	298 000
27.3.C 27.3.A 27.2.E	50	7½	744 570 707 940 540 480	5.871 5.887 5.733	657 000
27.3.E 27.4.A 27.4.B	40	22½	24 540 18 300 14 050	4.389 4.261 4.147	18 500
27.4.C 27.4.D 27.4.E	40	15	99 740 77 360 75 520	4.998 4.888 4.877	83 500
27.5.B 27.5.A 27.5.C	40	10	468 500 190 640 139 000	5.670 5.280 5.142	232 000
27.6.B 27.5.E 27.5.D	40	7½	12 684 000U 10 218 000U 351 400	7.102U 7.009U 5.545	>1 328 000
27.9.A 27.9.B 27.8.E	25	22½	35 960 27 800 23 180	4.555 4.445 4.362	28 500
27.7.B 27.7.A 27.7.C	25	15	61 710 41 960 31 890	4.790 4.622 4.503	43 500
27.7.D 27.7.E 27.8.A	25	10	206 820 157 950 142 540	5.315 5.197 5.153	167 000
27.8.C 27.8.D 27.8.B	25	7½	1 212 240 906 510 901 690	6.050 5.956 5.950	995 000
(g) Sheet 28 Speed of Testing - 3000 c.p.m. for S_m = 25°/o 1500 c.p.m. for S_m = 15°/o					
28.15.E	25	10	123 040	5.090	123 040
28.18.A 28.16.A	15	7½	10 000 000U 12 412 000U	7.000U 7.095U	>11 206 000
(h) Sheet 29 Speed of Testing - 3000 c.p.m.					
29.17.E 29.18.A	25	7½	12 352 000U 709 050	7.091U 5.850	>6 530 525
(j) Sheet 30 Speed of Testing - 3000 c.p.m. for S_m = 25°/o 1500 c.p.m. for S_m = 15°/o					
30.5.D	25	7½	992 770	5.996	992 770
30.4.A	15	7½	10 020 000U	7.000U	>10 020 000

U Unbroken

TABLE C.20 MEDIUM SPECIMENS LOOSE FIT PIN - PIN UNLOADED Reference Figure C.20

Specimen Type 2.A.5/16 d/D = 1/4 $K_t' = 2.43$

Tested by C.U.

Testing Machine, 6 Ton Losenhausen, Speed 1500 c.p.m.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
25.7.D 25.13.E 23.16.C(Fr)	50	22½	27 520 22 290 14 610	4.440 4.349 4.164	20 400
28.5.B 28.14.A 28.13.D	50	10	182 370 177 350 139 350	5.260 5.247 5.144	165 000
28.14.D 28.14.B 28.14.C	50	7½	445 210 433 980 421 970	5.648 5.636 5.250	435 000
28.16.B 28.16.C 28.15.A	40	22½	16 360 15 740 13 940	4.212 4.195 4.144	15 300
28.17.A 29.5.C 28.17.B	40	15	55 460 49 370 47 420	4.743 4.693 4.675	50 600
29.5.E 29.9.E 29.9.A	40	10	194 730 172 880 154 900	5.289 5.236 5.190	173 000
29.15.B(Fr) 29.10.D 29.12.A	40	7½	334 320 297 600 222 800	5.522 5.472 5.347	272 000
30.5.C 30.5.B 29.18.E	25	22½	30 860 22 130 20 700	4.490 4.345 4.315	24 200
30.8.A 30.7.A 30.8.B	25	15	56 610 55 320 54 170	4.752 4.743 4.735	55 400
30.9.E 30.8.C 30.9.B	25	10	415 320 171 970 134 350	5.618 5.235 5.127	212 000
30.10.C(Fr) 30.10.A 30.10.B	25	7½	818 260 390 210 254 170	5.912 5.490 5.404	433 000

(Fr) Specimen examined for fretting.

TABLE C.21 MEDIUM SPECIMENS PUSH FIT PIN - PIN UNLOADED Reference Figure C.21

Specimen Type 2.A.5/16 d/D = 1/4 $K_t' = 2.43$
Tested by C.U.
Testing Machine, 6 Ton Losenhausen, Speed 1500 c.p.m.
Range of Loads to insert pins, 20 to 350 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
22.15.A 22.13.D(Fr) 22.14.A	50	22½	72 040 44 190 42 090	4.857 4.645 4.623	51 100
23.2.D 22.18.D 23.2.C	50	15	158 390 139 040 116 900	5.200 5.143 5.069	137 000
23.17.D 23.17.E 23.2.E	50	10	307 620 224 060 214 250	5.487 5.350 5.330	246 000
24.5.A 24.6.B(Fr) 24.6.A	50	7½	6 256 000U 1 676 250 714 240	6.796U 6.224 5.850	>1 965 000
24.9.B 24.6.D 24.6.C	40	22½	120 180 89 680 71 770	5.080 4.942 4.855	91 900
24.9.D 24.11.A 24.11.B	40	15	196 070 162 460 151 720	5.292 5.210 5.180	169 000
25.11.A 25.2.C 25.10.C	40	10	229 940 214 180 113 480	5.360 5.330 5.055	177 000
25.15.C 26.18.B 25.17.C	40	7½	4 406 950U 2 080 410 872 640	6.645U 6.318 5.940	>2 000 000
26.7.D 26.6.E 26.6.C	25	22½	76 830 71 340 65 800	4.884 4.852 4.818	71 100
26.8.B 26.8.E 26.13.E	25	15	307 100 200 680 118 130	5.488 5.315 5.071	194 000
28.18.B 28.15.D 26.14.C	25	10	1 462 710 847 360 613 650	6.165 5.928 5.777	912 000
30.3.E(Fr) 30.3.B	25	7½	3 572 270U 2 501 290	6.552U 6.398	>2 980 000
22.14.C 22.14.E 22.13.A	15	12½	773 830 547 230 294 770	5.888 5.737 5.470	500 000
22.17.B 22.16.A 22.17.A	15	10	10 578 490U 2 828 260 719 230	7.024U 6.451 5.856	>2 780 000
22.17.D 22.17.C 22.17.E	15	7½	10 271 430U 830 810 637 430	7.012U 5.919 5.805	>1 755 000
23.1.A 22.18.B 22.18.A	15	5	10 691 480U 10 305 490U 8 204 620	7.029U 7.015U 6.914	>9 700 000

U Unbroken
(Fr) Specimen examined for fretting

TABLE C.22 MEDIUM SPECIMENS 0.4°/o INTERFERENCE FIT PIN **PIN UNLOADED**

Reference Figure C.22

Specimen Type 2.A.5/16 d/D = 1/4 K_t' varies with loading

Tested by C.U.

Testing Machine, 6 Ton Losenhausen Speed 1500 c.p.m.

Range of Loads to insert pins, 300 to 800 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
23.1.B 24.13.D 23.16.E	50	22½	31 270 29 480 24 660	4.495 4.469 4.392	28 000
26.2.A 26.2.C 26.2.E	50	15	66 570 60,310 58 970	4.822 4.780 4.770	62 000
26.3.E 26.4.A 26.3.B	50	10	175 550 167 280 143 220	5.244 5.223 5.155	161 000
26.4.C 26.4.D 26.4.E	50	7½	445 890 397 110 297 220	5.649 5.498 5.473	375 000
26.18.C 26.18.D 28.1.C	40	22½	71 700 62 300 29 160	4.856 4.794 4.464	51 000
28.3.C 28.1.D 28.1.A	40	15	92 800 85 660 52 030	4.966 4.933 4.716	75 000
28.4.D 28.3.D 28.3.E	40	10	267 640 248 660 222 630	5.425 5.396 5.346	246 000
28.5.D 28.5.C 28.5.E	40	7½	2 126 890U 2 118 830U 1 248 890	6.327U 6.325U 6.096	>1 779 000
28.10.A 28.6.D 28.6.B	25	22½	199 280 190 320 169 710	5.285 5.280 5.230	186 000
28.13.E 28.10.E 28.10.B	25	15	561 910 460 190 380 620	5.750 5.662 5.580	462 000
28.14.E 28.16.D 28.16.C	25	10	3 575 800U 2 132 320U 1 176 710	6.554U 6.328U 6.070	>2 078 000
29.1.D 29.2.B	25	7½	2 097 000U 2 055 940U	6.320U 6.312U	>2 076 000

U Unbroken

TABLE C.23 MEDIUM SPECIMENS 0.8°/o INTERFERENCE FIT PIN **PIN UNLOADED**

Reference Figure C.23

Specimen Type 2.A.5/16 d/D = 1/4 K_t' varies with loading

Tested by C.U.

Testing Machine, 6 Ton Losenhausen, Speed 1500 c.p.m.

Range of Loads to insert pins, 500 to 1300 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
22.15.E 22.14.B 22.14.D	50	22½	93 110 88 220 74 450	4.969 4.945 4.871	84 800
22.18.E 23.1.C 22.18.C	50	15	6 404 000U 418 000F 190 110	6.806U 5.622F 5.280	>800 000
23.2.A 23.1.D 23.2.B	50	10	2 380 000U 2 306 000U 504 600	6.276U 6.364U 5.703	>1 408 000
23.18.B 23.17.A 24.1.A	50	7½	4 204 600U 2 104 800U 2 100 100U	6.623U 6.322U 6.321U	>2 660 000
24.2.A 24.1.C 24.1.B	40	22½	308 960F 299 000 219 450	5.490F 5.476 5.340	> 272 000
24.2.C 24.2.B 24.13.A	40	15	1 316 300 1 036 860F 817 800	6.118 6.015F 5.912	>1 035 000
24.4.B 24.3.A 24.4.A	40	10	2 138 040U 2 096 380U 2 067 720U	6.329U 6.320U 6.315U	>2 100 000
24.5.B 24.5.C 24.4.C	40	7½	4 090 000U 2 100 100U 2 000 000U	6.612U 6.321U 6.301U	>2 585 000
24.8.B 24.7.A 24.7.C	25	22½	1 299 000F 1 090 300F 602 000	6.113F 6.037F 5.780	>950 000
24.9.A 24.10.A 24.9.C	25	15	6 413 000U 2 050 240U 1 289 200F	6.806U 6.311U 6.111F	>2 520 000
24.12.A 24.10.B 24.11.C	25	10	2 120 480U 2 118 530U 2 096 290U	6.326U 6.325U 6.320U	>2 100 000
24.12.B 24.15.B 24.12.C	25	7½	4 176 840U 2 069 700U 2 050 950U	6.620U 6.315U 6.311U	>2 580 000

U Unbroken

F Failed at full section away from Hole

TABLE C.24 MEDIUM SPECIMENS PUSH FIT PIN - PIN LOADED — Reference Figures C.24, C.24(a), C.24(b)

Specimen Type 2.B.5/16 $d/D = 1/4$ $K_t' = 3.73$

Tested by C.U.

Testing Machine, 6 Ton Losenhausen, Speed 1500 c.p.m.

Note There were two groups of specimens tested in this configuration and all specimens were taken from the same position along the sheet.

Group (a)

Range of Loads to insert pins 0 to 110 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
22.15.F 22.10.F 22.2.F	50	10	39 240 24 900 21 460	4.593 4.396 4.330	27 500
22.16.F 22.17.F 23.1.F	50	7½	67 320 45 550 33 300	4.827 4.658 4.521	46 700
23.6.F 23.5.F 23.3.F	40	10	82 660 54 070 47 970	4.916 4.733 4.680	62 900
23.9.F 23.7.F 23.8.F	40	7½	143 230 130 210 85 220	5.155 5.115 4.930	116 500
23.10.F 23.11.F	25	22½	9 870 8 750	3.994 3.942	9 310
23.16.F 23.15.F 25.1.F	25	10	84 950 69 530 55 860	4.929 4.842 4.745	69 000
25.15.F 25.13.F 25.14.F	25	7½	144 810 108 510 84 720	5.160 5.035 4.928	110 000

TABLE C.24 MEDIUM SPECIMENS PUSH FIT PIN - PIN LOADED

Reference Figures C.24, C.24(a), C.24(b)

Group (b) Range of loads to insert pins 20 to 250 lb except

25.2.F 300 lb
26.7.F, 22.7.F 400 lb
20.4.F 800 lb

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
19.3.F 18.11.F(Fr) 18.15.F	50	22½	6 370 6 020 4 380	3.803 3.780 3.631	5 520
19.9.F 19.8.F 19.13.F	50	15	14 170 13 640 11 120	4 150 4.135 4.045	12 900
20.2.F 20.4.F 20.3.F	50	10	24 640 24 170 23 390	4.390 4.384 4.367	24 100
21.14.F 21.3.F 21.12.F	50	7½	61 710 52 790 48 120	4.790 4.722 4.683	53 800
22.8.F 22.7.F 22.13.F	40	22½	6 940 6 810 6 460	3.841 3.833 3.810	6 740
22.14.F 23.4.F 23.2.F	40	15	12 100 11 950 11 640	4.082 4.077 4.065	11 900
25.2.F 23.13.F 25.3.F	40	10	40 860 30 190 26 420	4.610 4.480 4.421	32 000
25.4.F 25.6.F(Fr) 25.5.F	40	7½	67 210 63 130 46 660	4.827 4.800 4.669	58 200
25.7.F 25.8.F 25.9.F	25	22½	7 080 6 560 5 800	3.850 3.816 3.763	6 450
25.11.F 25.10.F 25.12.F	25	15	19 290 18 100 17 080	4.285 4.257 4.232	18 100
26.2.F 26.3.F 26.7.F	25	10	45 170 42 640 40 050	4.655 4.630 4.603	42 500
26.8.F 26.12.F(Fr) 26.11.F	25	7½	100 180 85 710 57 670	5.006 4.933 4.753	79 000

(Fr) Specimen examined for fretting

TABLE C.25 MEDIUM SPECIMENS 0.4°/o INTERFERENCE FIT PIN **PIN LOADED**

Reference Figure C.25

Specimen Type 2.B.5/16 d/D = 1/4 K_t' varies with loading

Tested by C.U.

Testing Machine, 6 Ton Losenhausen, Speed 1500 c.p.m.

Range of Loads to insert pins 350 to 650 lb.

Note All specimens taken from the same position along the sheet.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	**Geometric Mean Cycles**
	S_m	$\pm S_a$			
18.8.F 18.7.F 18.9.F	50	22½	6 030 5 530 4 220	3.780 3.743 3.625	5 000
18.12.F 18.13.F 18.10.F	50	15	44 290 29 180 25 340	4.646 4.465 4.403	32 000
18.16.F 19.2.F 18.14.F	50	10	32 380 25 270 22 590	4.509 4.402 4.353	26 000
19.7.F 19.12.F 19.6.F	50	7½	46 600 43 160 41 500	4.668 4.635 4.618	44 000
19.16.F 19.14.F 19.15.F 20.1.F	40	22½	8 340 7 660 5 820 3 520	3.920 3.885 3.765 3.546	6 000
20.7.F 20.6.F 20.5.F	40	15	18 000 16 910 16 760	4.255 4.228 4.224	17 000
20.9.F 20.10.F 20.8.F	40	10	40 460 35 130 30 570	4.606 4.545 4.485	35 000
20.11.F 20.13.F 20.12.F	40	7½	108 320 76 380 75 470	5.035 4.882 4.777	85 000
20.15.F 21.1.F 20.17.F	25	22½	9 650 7 900 7 240	3.983 3.898 3.859	8 000
21.2.F 21.4.F 21.5.F	25	15	39 470 29 350 25 500	4.596 4.467 4.405	31 000
21.7.F 21.6.F 21.8.F	25	10	88 000 78 800 67 990	4.943 4.896 4.832	78 000
21.13.F 21.9.F 21.10.F	25	7½	147 970 130 000 96 230	5.170 5.114 4.982	123 000
27.4.F 27.3.F 27.2.F	15	12½	184 430 128 270 95 890	5.265 5.109 4.991	131 500
27.5.F 27.6.F 27.7.F	15	10	331 040 264 340 251 660	5.519 5.421 5.400	280 000
27.8.F 27.9.F 27.10.F	15	7½	1 178 900 990 900 702 420	6.070 5.996 5.847	935 000
27.13.F 27.12.F 27.11.F	15	5	10 667 120U 10 487 260U 10 036 090U	7.028U 7.020U 7.014U	>10 500 000

U Unbroken

TABLE C.26 MEDIUM SPECIMENS 0.8°/o INTERFERENCE FIT PIN PIN LOADED

Reference Figure C.26

Specimen Type 2.B.5/16 d/D = 1/4 K_t' varies with loading
Tested by C.U.
Testing Machine, 6 Ton Losenhausen, Speed 1500 c.p.m.
Range of Loads to insert pins 450 to 1500 lb.

Note All specimens taken from the same position along the sheet.

Specimen Identification Number	Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
18.6.F 18.7.F 18.5.F	50	22½	7 850 7 180 5 060	3.895 3.855 3.705	6 570
19.17.F 19.5.F 21.11.F	50	15	23 210 22 280 17 380	4.365 4.347 4.239	20 800
21.17.F 21.16.F 21.15.F	50	10	45 320 36 160 29 000	4.655 4.558 4.462	36 200
22.3.F 22.18.F 22.1.F	50	7½	102 580 64 760 55 790	5.010 4.810 4.745	71 500
23.14.F 23.17.F 24.1.F	40	22½	10 600 8 780 8 140	4.025 3.943 3.910	9 100
24.3.F 24.2.F 24.5.F	40	15	32 180 29 590 19 870	4.507 4.471 4.297	28 450
24.8.F 24.6.F 24.7.F	40	10	67 770 57 250 47 500	4.830 4.757 4.677	57 000
24.11.F 24.10.F 24.9.F	40	7½	201 490 128 840 88 220	5.303 5.110 4.945	130 500
25.18.F 24.18.F 25.16.F	25	22½	10 480 9 020 8 370	4.020 3.955 3.922	9 280
26.4.F 26.1.F(Fr) 26.5.F	25	15	102 090 32 090 30 190	5.008 4.505 4.480	46 200
26.6.F 26.9.F 26.17.F	25	10	192 540 147 680 131 320	5.285 5.168 5.117	154 500
27.17.F 26.18.F(Fr) 27.1.F	25	7½	1 252 460 769 320 579 260	6.098 5.885 5.762	820 000

(Fr) Specimen examined for fretting

TABLE C.27 MEDIUM SPECIMENS UNFILLED HOLE — **Reference Figure C.27**

Specimen Type 2.C.15/32 d/D = 3/8 $K'_t = 2.28$
Tested by T.L.
Testing Machine, National Physical Laboratory,
Slipping Clutch Type, 6 Ton Capacity
Speed, 2500 to 3000 c.p.m.

Specimen Identification Number	Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
8.17.D 8.10.B 11.9.E	50	22½	66 000 57 000 24 000	4.820 4.755 4.380	45 000
8.5.B 8.5.A 8.1.D	50	15	450 000 240 000 130 000	5.653 5.380 5.115	242 000
8.6.E 11.11.C 11.11.A	50	10	113 000 96 000 83 000	5.052 4.981 4.919	96 000
11.12.D 11.13.E 11.11.E	50	7½	4 800 000 3 900 000 1 100 000	6.681 6.591 6.040	2 750 000
13.1.C 11.12.C 13.1.A	40	22½	33 000 32 000 27 000	4.518 4.505 4.430	30 500
11.14.A 11.12.B 11.15.B	40	15	390 000 180 000 80 000	5.590 5.255 4.903	177 500
13.1.D 11.10.C 13.4.B	40	10	820 000 620 000 96 000	5.913 5.792 4.981	365 000
13.2.A 13.3.D 8.15.B	40	7½	2 800 000 2 500 000 1 500 000	6.446 6.398 6.175	2 195 000
11.13.B 11.13.C	40	5	10 000 000U 10 000 000U	7.000U 7.000U	>10 000 000
11.14.E 13.2.D 13.1.B	25	22½	63 000 63 000 42 000	4.799 4.799 4.623	55 200
8.2.A 8.3.B 8.1.E	25	15	340 000 240 000 130 000	5.531 5.380 5.115	220 000
11.12.E 11.13.A 13.4.A	25	10	500 000 370 000 100 000	5.700 5.568 5.000	265 000
8.2.B 13.2.C 13.4.C	25	7½	2 400 000 1 500 000 890 000	6.380 6.175 5.950	1 475 000
11.15.C 8.19.B 8.18.D	15	12½	400 000 310 000 280 000	5.602 5.491 5.447	326 000
8.19.C 8.18.C 8.20.A	15	10	1 100 000 350 000 250 000	6.040 5.545 5.398	457 500
8.20.B 11.13.D 8.19.D	15	7½	10 000 000U 4 200 000 260 000	7.000U 6.623 5.415	>2 220 000
11.20.A 8.19.A 8.19.E	15	5	10 000 000U 10 000 000U 10 000 000U	7.000U 7.000U 7.000U	>10 000 000

U Unbroken

TABLE C.28 MEDIUM SPECIMENS PUSH FIT PIN - PIN UNLOADED Reference Figure C.28

Specimen Type 2.C.15/32 d/D = 3/8 $K_t' = 2.28$
Tested by T.L.
Testing Machine, National Physical Laboratory,
Slipping Clutch Type, 6 Ton Capacity, Speed 2500 to 3000 c.p.m.
Range of loads to insert pins not known.

Specimen Identification Number	Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
8.3.E 8.4.C 8.9.C	50	22½	140 000 81 000 72 000	5.145 4.907 4.857	93 700
8.6.B 8.4.A 8.5.C	50	15	420 000 320 000 80 000	5.622 5.505 4.902	220 000
8.5.D 8.7.B 8.9.B	50	10	350 000 285 000 260 000	5.544 5.454 5.415	297 000
8.4.E 8.4.D 8.3.C	50	7½	10 000 000U 4 400 000 1 250 000	7.000U 6.643 6.096	>3 790 000
8.8.C 8.9.A 8.7.C	40	22½	105 000 66 000 38 000	5.020 4.820 4.580	64 000
8.1.C 8.1.B 8.1.A	40	15	135 000 90 000 90 000	5.130 4.954 4.954	103 500
8.8.D 8.6.C	40	10	1 100 000 470 000	6.041 5.672	785 000
8.9.D 8.9.E 8.10.A	40	7½	8 700 000 1 500 000 1 400 000	6.939 6.175 6.145	2 630 000
8.8.B 8.2.D 8.3.A	25	22½	141 000 81 000 36 000	5.149 4.908 4.556	74 500
8.3.D 8.8.A 8.5.E	25	15	250 000 180 000 100 000	5.398 5.255 5.000	165 000
8.2.C 8.7.D 8.2.E	25	10	1 000 000 900 000 700 000	6.000 5.954 5.845	858 000
8.6.D 8.7.E 8.6.A	25	7½	4 700 000 1 900 000 450 000	6.672 6.279 5.653	2 670 000
7.11.A 7.10.E 7.12.A	15	12½	480 000 370 000 320 000	5.681 5.568 5.505	384 000
7.11.B 7.11.C 8.20.E	15	10	88 000 49 000 44 000	4.945 4.690 4.643	57 300
7.10.C 7.11.E 8.20.D	15	7½	10 000 000U 10 000 000U 1 200 000	7.000U 7.000U 6.079	>5 000 000
8.20.C 7.12.B 7.10.D	15	5	10 000 000U 10 000 000U 3 400 000	7.000U 7.000U 6.531	>6 900 000

U Unbroken

TABLE C.29 MEDIUM SPECIMENS UNFILLED HOLE Reference Figure C.29

Specimen Type 2.C.5/8 $d/D = 1/2$ $K_t' = 2.17$

Testing by C.U.

Testing Machine, 6 Ton Losenhausen, Speed 1500 c.p.m.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
3.4.D 3.8.C 3.4.C	50	22½	15 580 12 490 11 370	4.192 4.096 4.055	13 850
3.5.C 3.4.E 3.5.B	50	15	39 750 34 180 31 820	4.599 4.534 4.503	35 300
3.1.B 3.2.E 3.1.E	50	10	167 700 146 470 110 260	5.225 5.165 5.042	138 500
3.5.D 3.6.B 3.5.E	50	7½	311 600 246 510 243 860	5.493 5.391 5.387	265 000
3.7.B 3.6.E 3.6.D	40	22½	17 640 16 880 12 300	4.246 4.227 4.089	15 400
3.8.A 3.8.B 3.7.E	40	15	43 310 39 580 33 560	4.636 4.596 4.525	39 400
3.9.E 3.9.C 3.8.E	40	10	138 650 123 930 109 650	5.140 5.088 5.038	123 000
3.10.E 3.10.D 3.10.C	40	7½	358 150 245 510 240 930	5.555 5.390 5.382	277 000
3.11.C 3.11.B 3.11.A	25	22½	26 690 23 070 22 470	4.426 4.363 4.350	23 950
3.11.E 3.12.C 3.12.E	25	15	62 280 59 110 39 230	4.794 4.772 4.593	52 500
3.13.C 3.13.B 3.13.D	25	10	164 330 137 870 126 740	5.215 5.137 5.103	142 000
3.14.A 3.14.B 3.13.E	25	7½	292 270 277 470 224 480	5.465 5.442 5.350	268 000
3.15.C 3.14.D 3.14.E	15	12½	99 530 94 790 91 740	4.998 4.977 4.962	95 100
3.15.D 3.16.B 3.16.A	15	10	187 710 183 040 165 440	5.273 5.262 5.217	178 500
3.16.C 3.16.D 3.16.E	15	7½	642 260 463 320 277 990	5.808 5.666 5.445	420 000
3.17.C 3.17.D 3.17.A	15	5	1 578 970 997 660 872 130	6.198 5.999 5.940	1 115 000

TABLE C.30 MEDIUM SPECIMENS PUSH FIT PIN - PIN UNLOADED **Reference Figure C.30**

Specimen Type 2.C.5/8 d/D = 1/2 $K_t' = 2.17$

Tested by C.U.

Testing Machine, 6 Ton Losenhausen, Speed 1500 c.p.m.

Range of Loads to insert pins, 90 to 250 lb.

Specimen Identification Number	Stress Levels (o/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
3.18.C 3.18.B 3.17.E	50	22½	29 010 23 900 21 900	4.464 4.378 4.340	24 800
3.18.E 3.18.D 3.19.A	50	15	109 000 56 430 53 300	5.037 4.751 4.726	69 000
3.20.C 3.19.B 3.19.D	50	10	293 300 222 720 166 140	5.465 5.347 5.220	219 000
3.20.D 4.16.A 4.16.B	50	7½	748 740 474 740 356 650	5.874 5.675 5.552	505 000
4.16.C 4.16.E 4.16.D	40	22½	52 070 42 720 41 520	4.716 4.630 4.618	45 000
4.17.C 4.17.A 4.17.B	40	15	203 780 102 570 77 320	5.378 5.010 4.887	117 500
4.17.D 4.18.A	40	10	302 240 240 630	5.480 5.384	271 400

TABLE C.31 MEDIUM SPECIMENS $0.4^{o}/o$ INTERFERENCE FIT PIN PIN UNLOADED

Reference Figure C.31

Specimen Type 2.C.5/8 d/D = 1/2 K_t' varies with loading

Tested by C.U.

Testing Machine. 6 Ton Losenhausen, Speed 1500 c.p.m.

Range of Loads to insert pins, 1300 to 1700 lb.

Specimen Identification Number	Stress Levels ($^{o}/o$ Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
4.18.E 4.18.C 4.18.B(Fr)	50	22½	108 310 88 820 87 840	5.035 4.948 4.943	94 500
4.19.C 4.19.E 4.19.D	50	15	765 070 541 940 518 340	5.883 5.735 5.713	600 000
4.20.A 4.20.C 4.20.B	50	10	4 369 240 1 564 290 640 660	6.640 6.191 5.806	1 665 000
4.20.D 5.1.A 4.20.E	50	7½	10 497 480U 8 089 360 6 918 690	7.020U 6.907 6.840	>8 900 000
5.1.C(Fr) 5.1.B 5.1.D	40	22½	188 050 163 550 106 030	5.275 5.212 5.025	148 500
5.2.B 5.2.C 5.2.A	40	15	12 559 330 10 120 770 1 387 620	7.098 7.005 6.141	5 400 000
5.2.D(Fr) 5.3.A 5.2.E	40	10	12 094 460 10 750 410 10 529 230	7.082 7.030 7.023	11 100 000
5.5.B 5.3.D 5.5.A	25	22½	10 132 770U 10 025 230U 2 516 870	7.006U 7.002U 6.400	>6 350 000
5.5.D 5.5.E 5.5.C	25	15	12 953 340U 12 187 490U 10 422 150U	7.111U 7.085U 7.019U	>11 800 000
5.6.A 5.6.C 5.6.B	15	12½	12 645 050U 10 619 280U 10 550 530U	7.101U 7.026U 7.023U	>11 300 000

U Unbroken
(Fr) Specimen examined for fretting

TABLE C.32 MEDIUM SPECIMENS PUSH FIT PIN - PIN LOADED Reference Figure C.32

Specimen Type 2.D.5/8 d/D = 1/2 $K_t' = 2.22$

Tested by C.U.

Testing Machine, 6 Ton Losenhausen, Speed 1500 c.p.m.

Range of Loads to insert pins, 80 to 155 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
16.15.D 16.14.G 16.14.F	50	22½	32 700 24 000 22 500	4.515 4.380 4.352	26 000
16.16.F 16.16.A 16.16.B	50	15	85 710 81 020 54 520	4.932 4.908 4.736	71 500
16.17.B 16.17.D 16.17.E	50	10	321 000 137 010 121 860	5.506 5.136 5.084	174 500
16.18.C 16.17.F 16.18.E	50	7½	1 535 000 400 000 250 900	6.185 5.602 5.398	535 000
16.19.D 16.19.E 16.19.B	40	22½	38 640 28 750 23 180	4.587 4.458 4.365	28 500
17.1.C 16.20.C 16.20.G	40	15	94 000 64 270 42 260	4.973 4.808 4.625	63 800
17.3.D 17.2.F 17.2.C	40	10	260 450 185 170 138 240	5.416 5.268 5.140	188 000
17.3.G 17.4.D 17.4.C	40	7½	773 810 733 700 531 520	5.889 5.865 5.726	670 000
17.4.F 17.5.B 17.4.G	25	22½	44 700 32 390 20 140	4.650 4.510 4.302	30 700
17.5.C 17.5.F 17.5.D	25	15	123 220 76 540 75 790	5.090 4.883 4.880	83 800
17.5.G 17.7.B 17.8.B	25	10	433 590 414 230 147 990	5.636 5.616 5.170	298 000
17.8.D 17.8.E 17.9.D	25	7½	1 071 510 1 034 090 887 160	6.029 6.014 5 947	995 000
17.12.A 17.12.B 17.11.B	15	12½	367 250 316 460 310 950	5.565 5.500 5.492	325 000
17.13.B 17.12.D 17.13.E	15	10	2 207 390 864 690 334 320	6.344 5.936 5.522	858 000
17.14.F 17.13.F 17.14.E	15	7½	1 275 450 1 202 460 253 030	6.105 6.080 5.403	733 000
17.15.E 17.15.D	15	5	10 880 150U 10 046 500U	6.036U 6.018U	>10 463 000

U Unbroken

TABLE C.33 MEDIUM SPECIMENS 0.4°/o INTERFERENCE FIT PIN PIN LOADED

Reference Figure C.33

Specimen Type 2.D.5/8 d/D = 1/2 K_t' varies with loading

Tested by C.U.

Testing Machine, 6 Ton Losenhausen, Speed 1500 c.p.m.

Range of Loads to insert pins 700 to 1000 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
16.14.E(Fr) 16.14.D 16.15.B	50	22½	34 440 34 090 29 050	4.536 4.532 4.463	32 400
16.15.E 16.15.C 16.15.F	50	15	83 710 83 490 81 710	4.922 4.921 4.912	83 000
16.16.C 16.17.C 16.15.G	50	10	162 330 134 180 106 480	5.210 5.127 5.027	133 000
16.18.F 16.18.A 16.18.B	50	7½	258 820 244 750 198 390	5.412 5.388 5.296	232 000
16.19.F 16.19.A 16.20.A	40	22½	53 920 45 980 31 050	4.730 4.662 4.492	46 500
17.1.A 17.2.A 17.2.G	40	15	216 380 187 360 138 970	5.334 5.272 5.142	177 500
17.7.A 17.7.C(Fr) 17.7.E	40	10	992 290 424 570 405 780	5.996 5.627 5.608	555 000
17.7.G 17.9.A 17.7.F	40	7½	502 650 414 100 270 340	5.701 5.616 5.431	384 000
17.10.A(Fr) 17.10.E 17.9.F	25	22½	5 490 160 1 107 670 926 360	6.739 6.045 5.965	1 775 000
17.14.A 17.11.F 17.10.F	25	15	13 109 240U 10 417 860U 10 279 270U	7.116U 7.019U 7.011U	>11 300 000
17.16.A	15	12½	10 158 000U	7.005U	>10 158 000

U Unbroken

(Fr) Specimen examined for fretting

TABLE C.34 MEDIUM SPECIMENS 0.8 °/o INTERFERENCE FIT PIN PIN LOADED

Reference Figure C.34

Specimen Type 2.D.5/8 d/D = 1/2 K'_t varies with loading

Tested by C.U.

Testing Machine, 6 Ton Losenhausen, Speed 1500 c.p.m.

Range of Loads to insert pins, 700 to 1450 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
16.17.G 16.16.D 16.16.E	50	22½	165 000 130 310 110 000	5.216 5.115 5.041	133 000
16.20.E 16.18.D 16.18.G	50	15	10 648 000U 410 760 240 870	7.027U 5.614 5.381	>1 020 000
17.1.F 17.1.D 16.20.F	50	10	12 630 170U 10 349 610U 3 080 210J	7.102U 7.014U 6.488J	>7 420 000
17.3.C 17.1.G 17.4.B	40	22½	838 350F 819 750F 664 510F	5.992F 5.913F 5.821F	>780 000
17.4.E 17.5.A 17.5.E	40	15	10 860 000U 10 078 000U 6 498 000J	7.037U 7.004U 6.811J	>9 100 000
17.8.C 17.9.C 17.9.B	40	10	13 343 000U 10 288 000U 10 216 000U	7.124U 7.011U 7.009U	>11 200 000
17.11.C 17.10.D 17.10.B	25	22½	10 758 000U 4 138 000F 897 820F	7.031U 6.616F 5.953F	>3 420 000
17.12.E 17.9.G 17.11.G	25	15	10 180 000U 10 087 000U 10 009 000U	7.003U 7.002U 7.001U	>10 100 000

U Unbroken

J Failed at Jaws

F Failed across full section away from hole

TABLE C.35 SMALL SPECIMENS UNFILLED HOLE

Reference Figure C.35

Specimen Type $4.A_1.3/16$ d/D = 1/4 $K_t' = 2.43$

Tested by C.U.

Testing Machine, 2 Ton Amsler

Speed 7 000 c.p.m.*

Specimen Identification Number	Stress Levels (o/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
1.3.C 1.3.D 1.1.E	50	22½	21 000 21 000 20 000	4.322 4.322 4.301	20 600
1.4.B 1.3.G 1.3.F	50	15	80 000 67 000 63 000	4.903 4.825 4.799	69 700
1.15.G 1.13.A 1.9.F	50	10	10 000 000U 239 000 191 000	7.000U 5.378 5.280	>769 000
1.16.G 1.16.H 1.15.I	50	7½	12 326 000 10 000 000U 2 915 000	7.090 7.000U 6.464	>6 630 000
1.19.D 1.17.C 1.19.B	40	22½	23 000 21 000 12 000	4.361 4.322 4.078	18 000
1.20.G 1.21.A 1.20.D	40	15	66 000 64 000 53 000	4.820 4.806 4.725	60 700
1.22.I 1.21.B 1.22.A	40	10	287 000 240 000 176 000	5.457 5.380 5.245	229 000
2.7.J 2.3.J 2.3.E	40	7½	6 760 000 1 140 000 609 000	6.830 6.067 5.784	1 715 000
2.20.C 2.16.B 2.8.F	25	22½	50 000 42 000 17 000	4.699 4.623 4.230	32 900
9.14.B 9.14.A 9.13.F	15*	12½	3 540 000 226 000 222 000	6.549 5.354 5.345	560 000
9.19.D 9.15.G 9.14.G	15*	10	10 461 000U 2 017 000 338 000	7.020 U 6.305 5.528	>1 930 000
9.19.G 9.19.E 9.19.F	15*	7½	19 310 000U 10 457 000U 10 000 000U	7.285U 7.020U 7.000U	>13 000 000

*Type $4.A_2$ 3/16, tested at 8 000 c.p.m.

U unbroken

TABLE C.36 SMALL SPECIMENS LOOSE FIT PIN PIN UNLOADED

Reference Figure C.36

Specimen Type 4.A_1.3/16 d/D = 1/4 $K_t' = 2.43$
Tested by C.U.
Testing Machine, 2 Ton Amsler Speed 7 000 c.p.m.

Specimen Identification Number	Stress Levels (o/o Ultimate		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
1.4.G 1.4.J 1.4.C(Fr)	50	22½	32 000 29 000 8 000	4.505 4.462 3.903	19 500
1.8.D 1.8.C 1.8.B	50	15	221 000 153 000 66 000	5.344 5.185 4.820	130 800
1.10.F 1.10.C 1.8.H	50	10	280 000 150 000 127 000	5.447 5.175 5.103	176 000
1.12.D 1.17.I 1.13.J	50	7½	17 827 000U 746 000 438 000	7.252U 5.872 5.641	>1 472 000
1.18.J 1.20.E	40	22½	26 000 25 000	4.415 4.398	25 500
2.4.C 1.22.G 1.21.J	40	15	80 000 71 000 71 000	4.903 4.851 4.851	73 200
2.6.I(Fr) 2.7.A 2.4.I	40	10	236 000 169 000 142 000	5.374 5.227 5.152	178 000
2.7.D 2.7.I 2.8.E	40	7½	7 582 000 845 000 758 000	6.880 5.926 5.880	1 695 000
2.8.H 2.9.B 2.8.I	25	22½	54 000 44 000 36 000	4.732 4.643 4.556	44 100
3.2.I 3.2.E 3.1.I	25	15	98 000 94 000 81 000	4.991 4.973 4.908	90 600
3.10.C 3.10.H 3.2.J	25	10	7 524 000U 172 000 131 000	6.877U 5.235 5.117	>554 000
3.12.B 3.13.D 3.16.I(Fr)	25	7½	8 620 000U 690 000 542 000	6.935U 5.839 5.734	>1 480 000

U Unbroken

Fr Specimen examined for fretting

TABLE C.37 SMALL SPECIMENS PUSH FIT PIN - PIN UNLOADED Reference Figure C.37

Specimen Type $4.A_1.3/16$ $d/D = 1/4$ $K_t' = 2.43$

Tested by C.U.

Testing Machine, 2 Ton Amsler Speed 7 000 c.p.m.*

Range of Loads to insert pins, 2 to 150 lb.

Specimen Identification Numbers	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
1.19.I(Fr) 1.20.A 1.19.J	50	22½	45 000 32 000 31 000	4.653 4.505 4.490	35 500
1.20.B 1.20.H 1.20.F	50	15	174 000 120 000 116 000	5.240 5.080 5.064	134 000
2.2.F 1.22.H 1.20.I	50	10	494 000 254 000 177 000	5.694 5.404 5.247	281 000
2.6.G 2.2.J 2.3.H	50	7½	2 010 000U 952 000 461 000	6.303U 5.979 5.664	> 959 000
2.7.B 2.6.H 2.8.J	40	22½	123 000 113 000 65 000	5.089 5.053 4 813	96 000
2.14.H 2.14.J 2.9.I	40	15	241 000 186 000 62 000	5.382 5.269 4.792	140 700
2.19.E 2.15.I 2.17.G	40	10	377 000 345 000 226 000	5.575 5.537 5.354	308 000
2.22.G 2.22.E 2.22.H(Fr)	40	7½	2 134 000U 2 004 000U 682 000	6.328U 6.302U 5.827	>1 430 000
3.10.E 3.10.D 3.10.F	25	22½	130 000 112 000 75 000	5.114 5.049 4.875	103 000
3.11.A 3.11.C 3.11.J	25	15	1 068 000 185 000 155 000	6.028 5.267 5.190	312 000
3.12.G 3.13.F 3.19.I	25	10	8 593 000U 2 366 000 933 000	6.933U 6.374 5.962	>2 680 000
3.20.J 2.9.J(Fr)	25	7½	2 940 000U 2 150 000U	6.468U 6.332U	>2 500 000
1.1.C 1.2.D 1.2.E	15*	12½	11 920 000U 1 085 000 460 000	7.075U 6.035 5.563	>1 815 000
1.5.B 1.5.F 1.5.A	15*	10	18 289 000U 4 046 000 1 026 000	7.262U 6.606 6.010	>4 240 000
1.5.D 1.5.G 1.4.H	15*	7½	14 517 000U 14 313 000U 10 315 000U	7.162U 7.155U 7.012U	>12 850 000

*15°/o S_m specimens tested at 8 000 c.p.m.

U Unbroken

(Fr) Specimen examined for fretting

TABLE C.38 SMALL SPECIMENS 0.4°/o INTERFERENCE FIT PIN **PIN UNLOADED**

Reference Figure C.38

Specimen Type $4.A_1.3/16$ $d/D = 1/4$ K'_t varies with loading

Tested by C.U.

Testing Machine, 2 Ton Amsler Speed 8 000 c.p.m.

Range of Loads to insert pins, 120 to 310 lb.

Specimen Identification Numbers	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
1.1.J 1.1.B 1.1.G	50	22½	65 000 53 000 46 000	4.813 4.724 4.663	54 000
1.3.E 1.2.C 1.3.H	50	15	194 000 160 000 111 000	5.288 5.203 5.045	151 000
1.5.C 1.4.D 1.4.I	50	10	543 000 401 000 375 000	5.735 5.603 5.574	434 000
1.6.E 1.5.E 1.6.G	50	7½	2 566 000 1 210 000 1 097 000	6.410 6.082 6.039	1 505 000
1.7.B 1.6.I 1.7.A+	40	22½	154 000 150 000 148 000	5.188 5.175 5.170	151 000
1.7.H 1.7.C 1.7.F	40	15	293 000 275 000 260 000	5.467 5.440 5.415	276 000
1.9.I 1.10.J 1.8.G	40	10	6 758 000U 2 406 000U 2 116 000U	6.828U 6.382U 6.325U	>3 252 000
1.11.C 1.15.A 1.16.A	40	7½	7 427 000U 2 198 000U 1 292 000	6.870U 6.340U 6.110	>2 763 000
1.21.D 1.17.A 1.20.J	25	22½	2 000 000U 1 570 000 1 480 000F	6.301U 6.195 6.170F	>1 669 000
2.2.B 1.21.E 2.2.G	25	15	2 800 000U 2 324 000U 2 240 000U	6.447U 6.365U 6.350U	>2 443 000
2.4.B 2.4.G 2.4.E	25	10	7 540 000U 4 574 000U 2 102 000U	6.877U 6.660U 6.323U	>4 170 000
2.6.A 2.5.D 2.6.J	25	7½	7 549 000U 2 106 000U 2 000 000U	6.878U 6.324U 6.301U	>3 168 000

U Unbroken

F Failed at full section away from Hole

\+ See special comment and photographs, Appendix C paragraph C.3 and Figures C.51 and C.52.

TABLE C.39 SMALL SPECIMENS 0.8 °/o INTERFERENCE FIT PIN PIN UNLOADED

Reference Figure C.39

Specimen Type $4.A_1.3/16$ $d/D = 1/4$ K_t' varies with loading

Tested by C.U.

Testing Machine, 2 Ton Amsler Speed 7 000 c.p.m.

Range of Loads to insert pins, 270 to 500 lb.

Specimen Identification Numbers	Stress Levels (°/o Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
1.1.D 1.1.F 1.1.H	50	22½	290 000 266 000 124 000	5.462 5.425 5.093	213 000
1.2.A 1.1.I 1.2.B	50	15	903 000 380 000 281 000	5.955 5.580 5.448	459 000
1.2.H 1.4.A 1.2.G	50	10	7 500 000U 2 164 000U 2 132 000U	6.875U 6.335U 6.327U	>3 255 000
1.5.I 1.1.A 1.6.D	50	7½	7 415 000U 6 450 000U 2 122 000U	6.870U 6.809U 6.326U	>4 650 000
1.6.F 1.6.J 1.6.H	40	22½	311 000 290 000F 232 000	5.492 5.462F 5.365	>275 000
1.8.I 1.9.H 1.9.J	40	15	1 476 000F 1 019 000F 390 000F	6.168F 6.008F 5.590F	>766 000
1.11.D 1.11.I 1.11.J	40	10	2 840 000U 2 830 000U 2 263 000U	6.453U 6.451U 6.355U	>2 630 000
1.12.E 1.12.A 1.12.I	40	7½	15 120 000U 8 200 000U 2 120 000U	7.179U 6.913U 6.325U	>6 410 000
1.16.J 1.14.F 1.15.H	25	22½	706 000 492 000 457 000	5.849 5.692 5.660	584 000
1.18.D 1.17.H 1.17.G	25	15	3 761 000 2 055 000U 2 000 000U	6.575 6.312U 6.301U	>2 500 000
1.19.C 1.18.E 1.19.F	25	10	7 570 000U 2 000 120U 2 000 030U	6.878U 6.301U 6.301U	>3 120 000
1.22.D 1.19.G 1.21.I	25	7½	7 512 000U 7 220 000U 2 140 000U	6.876U 6.858U 6.330U	>4 525 000

U Unbroken

F Failed at full section away from Hole

TABLE C.40 SMALL SPECIMENS PUSH FIT PIN - PIN LOADED Reference Figure C.40 and C.40(a)

Specimen Type $4.B_1.3/16$ d/D = 1/4 $K'_t = 3.73$

Tested by C.U.

Testing Machine, 2 Ton Amsler Speed 7 500 to 8 000 c.p.m.

Range of Loads to insert pins, 0 to 300 lb.

Specimen Identification Number	Stress Levels (o/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
	Group (a) - Type 4 B_1 3/16*				
11.11.D 11.10.L 11.10.C	50	22½	17 000 11 000 8 000	4.230 4.041 3.903	11 000
11.11.E 11.11.G 11.11.I	50	15	26 000 18 000 12 000	4.415 4.255 4.078	18 000
11.11.K 11.11.N 11.12.A	50	10	59 000 23 000 16 000	4.770 4.361 4.204	28 000
11.12.B 11.12.G 11.12.C	50	7½	176 000 114 000 37 000	5.245 5.056 4.568	91 000
11.12.J 11.12.H 11.12.M	40	22½	25 000 12 000 10 000	4.398 4.078 4.000	14 000
11.14.D 11.13.M 11.14.L	40	15	27 000 25 000 20 000	4.430 4.398 4.301	24 000
11.16.C 11.15.G 11.16.B	40	10	52 000 51 000 42 000	4.715 4.707 4.623	48 000
11.16.N 11.16.O 11.16.M	40	7½	807 000 420 000 145 000	5.907 5.623 5.160	366 000
11.11.J 11.12.L 11.12.I	25	22½	21 000 20 000 13 000	4.322 4.301 4.114	18 000
11.14.K 11.12.N 11.14.E	25	15	41 000 38 000 35 000	4.612 4.580 4.545	38 000
11.15.F 11.15.C 11.11.M	25	10	186 000 58 000 40 000	5.269 4.763 4.602	76 000
11.15.O 11.15.K 11.17.A	25	7½	442 000 143 000 104 000	5.645 5.155 5.017	187 000

*All Group (a) specimens tested at 7 800 c.p.m.

(Table continued on next page)

TABLE C.40 SMALL SPECIMENS PUSH FIT PIN - PIN LOADED (cont.)

Reference Figure C.40 and C.40(b)

Specimen Type $4.B_2.3/16$ $d/D = 1/4$ $K'_t = 3.73$

Specimen Identification Number	Stress Levels ($^o/o$ Ultimate) S_m	$\pm S_a$	Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	Group (b) - Type 4 B_2 3/16*				
12.2.O 12.3.F 12.2.N	50	10	57 000 43 000 20 000	4.755 4.633 4.301	36 000
12.4.C 12.3.H 12.4.B	50	7½	261 000 110 000 56 000	5.415 5.040 4.748	117 000
12.4.K 12.4.L 12.4.N	40	10	66 000 42 000 32 000	4.819 4.623 4.505	44 000
12.5.D 12.5.D 12.5.N	40	7½	193 000 115 000 112 000	5.285 5.060 5.049	135 500
12.6.H 12.6.I	25	22½	29 000 14 000	4.462 4.415	21 500
12.6.M 12.6.L 12.6.K	25	10	194 000 122 000 109 000	5.288 5.086 5.037	137 000
12.7.B 12.6.N 12.6.O	25	7½	724 000 558 000 162 000	5.860 5.745 5.209	435 000
12.4.E 12.4.F 12.4.D	15*	12½	40 000 37 000 32 000	4.602 4.568 4.505	36 200
12.7.K 12.5.L 12.7.C	15*	10	74 000 69 000 65 000	4.868 4.838 4.813	69 200
12.7.L 12.8.D 12.8.A	15*	7½	137 000 111 000 65 000	5.136 5.045 4.813	123 700
12.8.F 12.10.L 12.8.E	15*	5	200 000 182 000 166 000	5.301 5.260 5.220	183 700

* All tested at 8 000 c.p.m., except those at $S_m = 15^o/o$ which were at 7 500 c.p.m.

TABLE C.41 SMALL SPECIMENS 0.4^{o}/o INTERFERENCE FIT PIN PIN LOADED

Reference Figure C.41

Specimen Type 4.B_1.3/16 d/D = 1/4 K_t' varies with loading

Tested by C.U.

Testing Machine, 2 Ton Amsler Speed 8 000 c.p.m.*

Range of Loads to insert pins, 65 to 370 lb.

Specimen Identification Number	Stress Levels (^{o}/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
11.10.A 11.10.D 11.10.E	50	22½	11 000 8 000 6 000	4.040 3.903 3.778	8 000
11.10.H 11.10.I 11.10.J	50	15	21 000 18 000 16 000	4.321 4.255 4.204	18 000
11.10.K 11.11.O 11.11.H	50	10	56 000 33 000 31 000	4.747 4.519 4.490	39 000
11.13.A 11.13.B 11.13.E	50	7½	104 000 104 000 102 000	5.016 5.016 5.009	103 000
11.13.H 11.13.F 11.13.G	40	22½	20 000 19 000 16 000	4.301 4.279 4.204	18 000
11.13.K 11.13.J 11.13.I	40	15	29 000 22 000 20 000	4.462 4.342 4.301	23 000
11.13.L 11.13.N 11.13.O	40	10	72 000 58 000 53 000	4.858 4.762 4.724	60 000
11.14.B 11.14.F 11.14.A	40	7½	187 000 166 000 118 000	5.272 5.220 5.071	154 000
11.14.I 11.14.H 11.14.G	25	22½	26 000 19 000 14 000	4.415 4.279 4.146	19 000
11.14.J 11.17.H 11.14.M	25	15	66 000 50 000 40 000	4.820 4.699 4.602	51 000
11.15.B 11.14.O 11.14.N	25	10	284 000 87 000 84 000	5 453 4.939 4.925	128 000
11.15.I 11.15.J 11.15.H	25	7½	19 162 000U 2 141 000U 1 026 000	7.281U 6.330U 6.010	>3 478 000
11.15.A 11.10.O 11.13.D	15*	12½	147 000 93 000 83 000	5.166 4.968 4.918	104 300
11.15.M 11.18.A 11.16.I	15*	10	362 000 334 000 155 000	5.558 5.523 5.190	265 000
11.18.N 11.18.M 11.18.L	15*	7½	655 000 426 000 352 000	5.815 5.629 5.545	460 000
11.19.J 11.19.F 11.19.E	15*	5	1 019 000 614 000 361 000	6.007 5.787 5.557	608 000

*Except those at S_m = 15^{o}/o which were tested at 7 800 c.p.m.

U Unbroken

TABLE C.42 SMALL SPECIMENS 0.8 $^{o}/o$ INTERFERENCE FIT PIN PIN LOADED

Reference Figure C.42

Specimen Type $4.B_1.3/16$ d/D = 1/4 K_t' varies with loading

Tested by C.U.

Testing Machine, 2 Ton Amsler Speed 8 000 c.p.m.*

Range of Loads to insert pins, 300 to 450 lb.

Specimen Identification Number	Stress Levels ($^{o}/o$ Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
11.10.M 11.11.F	50	15	15 000 15 000	4.175 4.175	15 000
11.13.C 11.12.K	50	10	24 000 18 000	4.380 4.255	21 000
11.16.A 11.14.C 11.15.L	50	7½	56 000 55 000 35 000	4.747 4.740 4.544	47 700
11.17.D 11.17.B 11.17.C	40	22½	11 000 10 000 8 000	4.040 4.000 3.903	9 600
11.17.J 11.17.K 11.17.I	40	15	27 000 27 000 18 000	4.430 4.430 4.255	23 600
11.17.L 11.17.M 11.17.O	40	10	70 000 65 000 58 000	4.845 4.812 4.763	64 100
11.18.C 11.18.E 11.18.B	40	7½	75 000 71 000 69 000	4.875 4.850 4.838	71 400
11.18.H 11.18.G 11.18.F	25	22½	24 000 22 000 20 000	4.380 4.342 4.301	22 800
11.18.J 11.18.K 11.18.I	25	15	82 000 74 000 61 000	4.914 4.869 4.785	72 000
11.18.O 11.19.C 11.19.D	25	10	220 000 110 000 100 000	5.342 5.041 5.000	134 000
11.19.M 11.19.H 11.19.G	25	7½	521 000 263 000 256 000	5.717 5.420 5.408	327 500
11.17.G	15*	12½	616 000	5.789	616 000

*Except for the one specimen at $S_m = 15^{o}/o$ which was tested at 7 800 c.p.m.

TABLE C.43 SMALL SPECIMENS UNFILLED HOLE   Reference Figure C.43

Specimen Type 4.C.9/32   d/D = 3/8 $K'_t = 2.28$

Tested by T.L.

Testing Machine, National Physical Laboratory,

Slipping Clutch Type, 2 Ton Capacity, Speed 2 500 to 3 000 c.p.m.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
16.19.A 13.9.D	50	22½	39 000 33 000	4.590 4.518	36 000
13.12.H 16.10.J	50	15	110 000 66 000	5.040 4.820	88 000
14.21.C 14.21.J	50	12½	150 000 130 000	5.175 5.114	140 000
16.15.E 14.7.J 16.1.H	50	10	10 000 000U 300 000 200 000	7.000U 5.477 5.301	>845 000
14.1.G 13.12.F 13.9.H	50	7½	10 000 000U 1 600 000 500 000	7.000U 6.204 5.699	>2 000 000
16.19.J 16.19.H 14.1.C	40	22½	51 000 36 000 27 000	4.707 4.555 4.430	34 000
16.19.C 14.1.F 16.1.J	40	15	110 000 75 000 50 000	5.040 4.875 4.699	74 600
15.6.J 16.16.H 13.9.I	40	10	550 000 320 000 285 000	5.740 5.505 5.455	365 000
15.7.E 14.1.E 14.1.D	40	7½	1 300 000 525 000 260 000	6.115 5.720 5.415	560 000
6.20.I 13.9.B 16.15.J	25	22½	42 000 21 000 21 000	4.623 4.322 4.322	26 400
14.13.D 13.8.H 14.21.E	25	15	240 000 75 000 72 000	5.380 4.875 4.857	109 000
15.7.D 13.9.E 15.1.J	25	10	10 000 000 560 000U 260 000U	7.000 5.748U 5.415U	>1 130 000
14.1.B 16.15.F 13.9.J	25	7½	10 000 000U 135 000 130 000	7.000U 5.130 5.114	>560 000
13.15.B 13.15.A 13.15.F	15	12½	240 000 200 000 150 000	5.380 5.301 5.175	193 000
13.26.F 13.26.G 13.26.A	15	10	10 000 000U 10 000 000U 990 000	7.000U 7.000U 5.995	>4 625 000
13.6.H 13.8.B 13.8.G	15	7½	10 000 000U 10 000 000U 10 000 000U	7.000U 7.000U 7.000U	>10 000 000
13.14.J 13.9.F 13.14.G	15	5	10 000 000U 10 000 000U 10 000 000U	7.000U 7.000U 7.000U	>10 000 000

U   Unbroken

TABLE C.44 SMALL SPECIMENS PUSH FIT PIN - PIN UNLOADED Reference Figure C.44

Specimen Type 4.C.9/32 d/D = 3/8 $K_t^{'} = 2.28$

Tested by T.L.

Testing Machine, National Physical Laboratory,

Slipping Clutch Type 2 Ton Capacity Speed 2 500 to 3 000 c.p.m.

Range of loads to insert pins, not known.

Specimen Identification Number	Stress Levels (o/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
17.14.I 17.7.E 17.15.G	50	15	280 000 180 000 120 000	5.446 5.255 5.079	182 500
17.14.E 17.14.B 17.16.C	50	10	2 100 000 1 700 000 400 000	6.321 6.230 5.602	1 120 000
17.16.J 17.14.G 17.15.I	50	7½	10 000 000U 5 900 000 1 900 000	7.000U 6.770 6.278	>4 830 000
13.8.A 14.17.A 17.16.F	40	22½	72 000 60 000 57 000	4.857 4.777 4.755	62 600
17.17.C 17.14.D 17.16.I	40	15	160 000 150 000 100 000	5.204 5.175 5.000	134 000
17.15.H 17.17.F 13.29.G	40	10	3 700 000 2 200 000 120 000	6.568 6.342 5.079	990 000
13.29.I 17.14.J 17.16.B	40	7½	10 000 000U 10 000 000U 2 000 000	7.000U 7.000U 6.301	>5 870 000
17.14.F 17.16.A 17.15.E	25	22½	99 000 57 000 42 000	4.995 4.755 4.623	62 000
17.16.G 17.17.A 17.16.H	25	15	260 000 210 000 170 000	5.415 5.322 5.230	210 000
17.14.C 17.17.B 17.17.D	25	10	890 000 840 000 340 000	5.900 5.924 5.531	633 000
17.15.B 13.29.H 17.14.A	25	7½	10 000 000U 10 000 000U 6 100 000	7.000U 7.000U 6.785	>8 480 000
17.18.B 13.9.A 17.15.C	15	12½	220 000 190 000 190 000	5.342 5.278 5.278	200 000
17.14.H 17.15.F 17.16.D	15	10	9 400 000 4 400 000 1 040 000	6.973 6.643 6.016	3 500 000
17.18.A 17.15.J 17.15.D	15	7½	10 000 000U 10 000 000U 10 000 000U	7.000U 7.000U 7.000U	>10 000 000
17.16.E 17.15.A 17.18.G	15	5	10 000 000U 10 000 000U 10 000 000U	7.000U 7.000U 7.000U	>10 000 000

U Unbroken

TABLE C.45 SMALL SPECIMENS UNFILLED HOLE   Reference Figure C.45

Specimen Type 4.C.3/8   d/D = 1/2 $K'_t = 2.17$

Tested by C.U.

Testing Machine, 2 Ton Amsler   Speed 8 000 c.p.m.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
19.1.E 19.1.C 19.1.A	50	22½	32 000 18 000 14 000	4.505 4.255 4.145	20 000
19.6.A 19.5.A 19.4.I	50	15	69 000 54 000 51 000	4.839 4.732 4.707	58 000
19.6.H 19.6.D 19.6.I	50	10	249 000 242 000 214 000	5.395 5.383 5.330	234 000
19.6.J 18.28.D 18.3.B	50	7½	9 220 000U 4 515 000 275 000	6.964U 6.655 5.439	>2 254 000
19.7.F 19.7.B 19.7.A	40	22½	22 000 22 000 19 000	4.342 4.342 4.278	21 000
19.8.J 19.8.I 19.8.H	40	15	65 000 65 000 60 000	4.812 4.812 4.777	63 000
19.9.I 19.9.B 19.9.A	40	10	145 000 131 000 127 000	5.160 5.117 5.104	134 000
19.11.I 19.10.J 19.11.G	40	7½	10 282 000U 379 000 299 000	7.012U 5.578 5.475	>1 052 000
19.12.G 19.12.H 19.13.A	25	22½	58 000 51 000 48 000	4.763 4.707 4.681	52 000
19.13.B 19.15.F 19.13.H	25	15	170 000 126 000 78 000	5.230 5.100 4.891	119 000
19.16.B 19.16.C 19.16.E	25	10	509 000 306 000 288 000	5.699 5.485 5.460	353 000
19.17.A 19.16.G 19.17.F	25	7½	7 521 000U 2 000 000U 1 844 000	6.876U 6.301U 6.265	>3 027 000
17.2.H 17.2.I 17.4.C	15	12½	1 867 000 788 000 402 000	6.270 5.896 5.604	840 000
17.4.E 17.5.E 17.5.B	15	10	12 260 000U 10 046 000 10 036 000	7.088U 7.002 7.002	>10 050 000

U   Unbroken

TABLE C.46 SMALL SPECIMENS PUSH FIT PIN - PIN UNLOADED **Reference Figure C.46**

Specimen Type 4.C.3/8 d/D = 1/2 $K_t' = 2.17$

Tested by C.U.

Testing Machine, 2 Ton Amsler Speed 7 000 c.p.m.

Range of Loads to insert pins, 45 to 200 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
17.17.B 17.1.A 17.1.C	50	22½	35 000 32 000 27 000	4.543 4.505 4.430	31 000
17.1.F 17.1.E 17.1.D	50	15	182 000 134 000 125 000	5.260 5.126 5.096	145 000
17.1.H 17.1.I 17.1.G	50	10	418 000 372 000 238 000	5.621 5 570 5.376	363 000
17.1.J 17.2.C 17.2.A	50	7½	2 289 000U 2 107 000U 628 000	6.359U 6.324U 5.797	>1 447 000
17.2.F 17.2.E 17.2.D	40	22½	65 000 51 000 47 000	4.812 4.707 4.671	54 000
17.2.J 17.3.A 17.2.G	40	15	460 000 361 000 317 000	5.662 5.556 5.500	375 000
17.3.D 17.3.B 17.3.C	40	10	2 532 000U 2 000 000U 485 000	6.404U 6.301U 5.685	>1 909 000
17.3.G 17.3.E 17.3.F	40	7½	7 172 000U 2 695 000U 2 210 000U	6.855U 6.430U 6.343U	>3 496 000
17.4.A 17.3.H 17.4.B	25	22½	325 000 71 000 56 000	5.512 4.850 4.748	109 000
17.4.F 17.4.D 17.4.G	25	15	8 364 000U 315 000 244 000	6.922U 5.498 5.388	>863 000
17.4.I 17.4.J 17.4.H	25	10	3 325 000U 2 053 000U 2 043 000U	6.522U 6.313U 6.310U	> 2 407 000
17.5.C 17.5.A 17.5.D	25	7½	19 906 000U 2 200 000U 2 004 000U	7.298U 6.342U 6.302U	>4 444 000
17.6.I 17.7.A 17.6.G	15	12½	12 860 000U 10 993 000U 1 827 000	7.110U 7.040U 6.260	>6 350 000
17.7.E 17.7.B 17.7.F	15	10	15 260 000U 13 044 000U 700 000	7.185U 7.115U 5.545	>5 180 000
17.7.H 17.7.J 17.8.A	15	7½	10 528 000U 10 410 000U 10 354 000U	7.022U 7.017U 7.015U	>10 420 000

U Unbroken

TABLE C.47 SMALL SPECIMENS 0.4°/o INTERFERENCE FIT PIN **PIN UNLOADED**

Reference Figure C.47

Specimen Type 4.C.3/8 d/D = 1/2 K_t' varies with loading

Tested by C.U.

Testing Machine, 2 Ton Amsler Speed 6 800 c.p.m.

Range of Loads to insert pins, 450 to 550 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
17.12.D 17.8.G 17.8.E	50	22½	451 000 277 000 253 000	5.653 5.442 5.402	316 000
17.8.J 17.8.I 17.8.H	50	15	6 709 000 2 539 000 1 523 000	6.827 6.404 6.183	2 690 000
17.9.C 17.9.B 17.9.A	50	10	27 616 000U 10 766 000U 10 025 000U	7.440U 7.031U 7.012U	>12 900 000
17.10.E 17.10.F 17.10.G 17.10.I 17.9.G 17.9.I 17.9.H 17.10.D	40	22½	17 372 000U 12 216 000U 11 697 000U 10 377 000U 2 954 000J 1 406 000J 973 000J 622 000	7.238U 7.087U 7.068U 7.015U 6.470J 6.148J 5.973J 5.794	>6 410 000
17.9.J 17.10.L 17.10.B	40	15	12 283 000U 12 095 000U 11 314 000U	7.088U 7.082U 7.053U	>11 900 000
17.11.G 17.11.H 17.11.B 17.11.A	25	22½	27 289 000U 12 253 000U 11 393 000U 6 955 000J	7.436U 7.088U 7.056U 6.842J	>15 000 000
17.11.D 17.11.C 17.11.E	25	15	16 810 000U 14 361 000U 12 704 000U	7.225U 7.156U 7.103U	>14 500 000

U Unbroken

J Failed at the Jaws

TABLE C.48 SMALL SPECIMENS PUSH FIT PIN - PIN LOADED **Reference Figure C.48**

Specimen Type 4.D.3/8 d/D = 1/2 $K'_t = 2.22$

Tested by C.U.

Testing Machine, 2 Ton Amsler Speed 7 000 c.p.m.*

Range of loads to insert pins, 65 to 380 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
22.4.A 22.4.C 22.4.B	50	22½	17 000 16 000 14 000	4.230 4.205 4.145	16 000
22.4.M 22.4.H 22.4.G	50	15	55 000 47 000 36 000	4.740 4.672 4.555	45 000
22.6.F 22.10.M 22.5.G	50	10	390 000 270 000 222 000	5.462 5.430 5.345	286 000
22.15.L 22.14.I 22.15.N	50	7½	1 617 000 409 000 407 000	6.208 5.611 5.609	646 000
22.29.D 23.2.K 22.29.E	40	22½	96 000 80 000 73 000	4.982 4.902 4.864	82 000
23.3.M 23.5.F 23.5.O	40	15	244 000 181 000 173 000	5.385 5.256 5.237	197 000
23.9.D 23.6.L 23.7.K	40	10	2 000 000U 1 194 000 987 000	6.301U 6.075 5.994	>1 331 000
23.10.G 23.9.J 23.10.E	40	7½	2 002 000 1 323 000 1 226 000	6.301 6.121 6.089	1 481 000
23.14.D 23.13.N 23.10.J	25	22½	44 000 39 000 37 000	4.643 4.590 4.568	40 000
23.14.F 23.14.N 23.15.A	25	15	476 000 434 000 343 000	5.677 5.637 5.535	414 000
23.16.C 23.15.N 23.16.D	25	10	1 103 000 928 000 705 000	6.042 5.966 5.848	897 000
23.17.N 23.16.O 23.17.O	25	7½	2 131 000U 2 082 000 2 013 000U	6.328U 6.318 6.303U	>2 075 000
22.4.J 22.5.B 22.4.I	15*	12½	216 000 187 000 184 000	5.333 5.271 5.265	196 000
22.5.J 22.5.D 22.5.N	15*	10	700 000 253 000 198 000	5.845 5.401 5.296	326 000
22.6.I 22.6.B 22.6.J	15*	7½	1 148 000 1 055 000 550 000	6.060 6.022 5.740	873 000
22.6.M 22.7.J 22.7.B	15*	5	28 330 000U 10 320 000U 10 280 000U	7.451U 7.012U 7.010U	>14 200 000

U **Unbroken**

***Except** S_m **15°/o which were tested at 7 800 c.p.m.**

TABLE C.49 SMALL SPECIMENS 0.4 °/o INTERFERENCE FIT PIN PIN LOADED

Reference Figure C.49

Specimen Type 4.D.3/8 d/D = 1/2 K'_t varies with loading

Tested by C.U.

Testing Machine, 2 Ton Amsler Speed 7 700 c.p.m.

Range of loads to insert pins, 220 to 440 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
22.6.H 22.6.G 22.6.L	50	22½	53 000 39 000 12 000	4.725 4.591 4.078	29 200
22.6.O 22.7.C 22.6.N	50	15	202 000 139 000 101 000	5.305 5.142 5.005	142 000
22.7.E 22.7.F 22.7.G	50	10	637 000 255 000 159 000	5.804 5.405 5.200	296 000
22.7.L 22.7.H 22.7.M	50	7½	359 000 332 000 297 000	5.555 5.522 5.472	327 000
22.7.N 22.8.B 22.7.O	40	22½	155 000 123 000 107 000	5.190 5.090 5.030	127 000
22.8.D 22.8.F 22.8.C	40	15	792 000 323 000 205 000	5.900 5.509 5.310	375 000
22.8.J 22.8.H 22.8.K	40	10	13 031 000U 7 759 000 922 000	7.114U 6.890 5.964	>4 650 000
22.10.L 22.8.N 22.8.L 22.10.N 22.8.M 22.11.A 22.11.F	40	7½	13 846 000 11 952 000U 11 404 000U 11 257 00 10 397 000U 814 000 385 000	7.140 7.077U 7.056U 7.052 7.016U 5.910 5.585	>4 920 000
22.11.E 22.9.C 22.11.B 22.11.D 22.11.C 22.9.B	25	22½	12 313 000U 11 296 000U 4 096 000J 2 543 000J 1 103 000 457 000	7.090U 7.052U 6.611J 6.405J 6.043 5.658	>3 000 000
22.9.G 22.9.D 22.9.F	25	15	29 743 000U 12 370 000U 10 796 000U	7.472U 7.092U 7.033U	>15 250 000
22.10.G 22.10.D 22.10.E	15	12½	12 563 000U 12 275 000U 10 657 000U	7.098U 7.089U 7.028U	>11 850 000

U Unbroken

J Failed at Jaws

TABLE C3.50 SMALL SPECIMENS 0.8°/o INTERFERENCE FIT PIN **PIN LOADED**

Reference Figure C.50

Specimen Type 4.D.3/8 d/D = 1/2 K_t' varies with loading

Tested by C.U.

Testing Machine, 2 Ton Amsler Speed 8 000 c.p.m.

Range of loads to insert pins, 50 to 900 lb.

Specimen Identification Number	Stress Levels (°/o Ultimate)		Cycles to Failure	Logarithm Cycles to Failure	Geometric Mean Cycles
	S_m	$\pm S_a$			
22.10.F 22.12.F 22.12.G	50	22½	2 148 000 960 000J 602 000J	6.331 5.981J 5.780J	>1 075 000
22.12.L 22.12.K 22.13.A	50	15	31 030 000 13 637 000U 12 418 000U	7.492 7.135U 7.095U	>17 400 000
22.14.J 22.14.G 22.13.C	50	10	21 439 000U 13 551 000U 10 059 000U	7.330U 7.130U 7.024U	>14 550 000
22.14.O 22.14.N 22.14.K	50	7½	31 425 000U 14 242 000U 11 091 000U	7.497U 7.153U 7.045U	>17 000 000
22.15.A 22.17.G 22.15.B	40	22½	11 056 000U 10 727 000U 568 000J	7.042U 7.035U 5.753J	>9 800 000
22.18.J 22.18.B 22.18.A	40	15	11 635 000U 11 515 000U 8.012 000J	7.066U 7.061U 6.904J	>10 250 000
22.18.K 22.19.G 22.18.M	40	10	22 913 000U 11 535 000U 11 250 000U	7.360U 7 060U 7.050U	>14 350 000
22.20.A 22.20.D 22.20.E	25	22½	13 340 000U 12 333 000U 10 156 000U	7.124U 7.090U 7.005U	>11 850 000

U Unbroken

J Failed at Jaws

 FIG C.1 LARGE SPECIMENS – TYPE 1A½ ($w/D = 1/4$)

UNFILLED HOLE $S_m/f_t = 0.50, 0.40, 0.25$ & 0.15

($S_m/f_t = 0.4$ from FIG. C.1(a))

REF: TABLE C.1

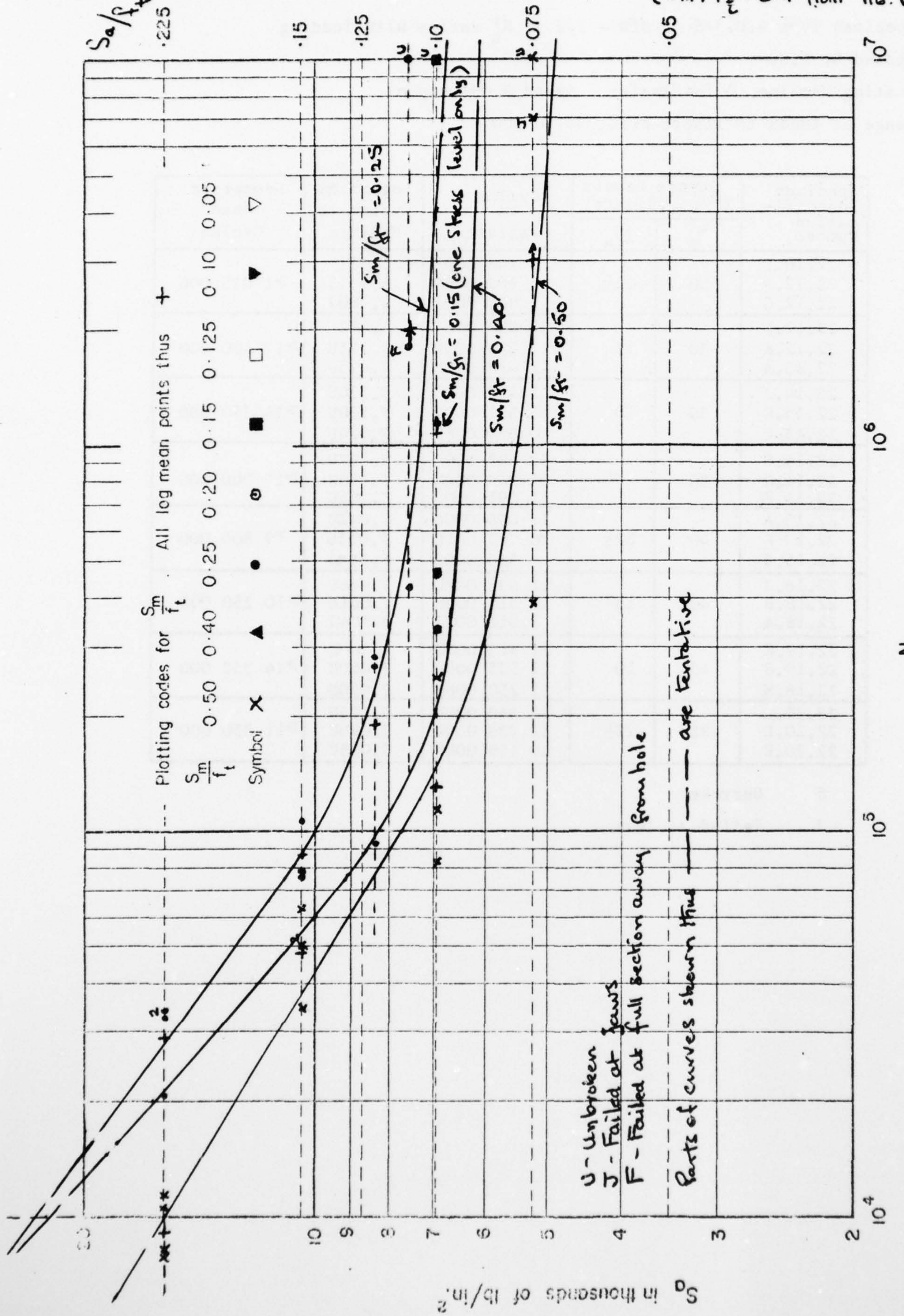
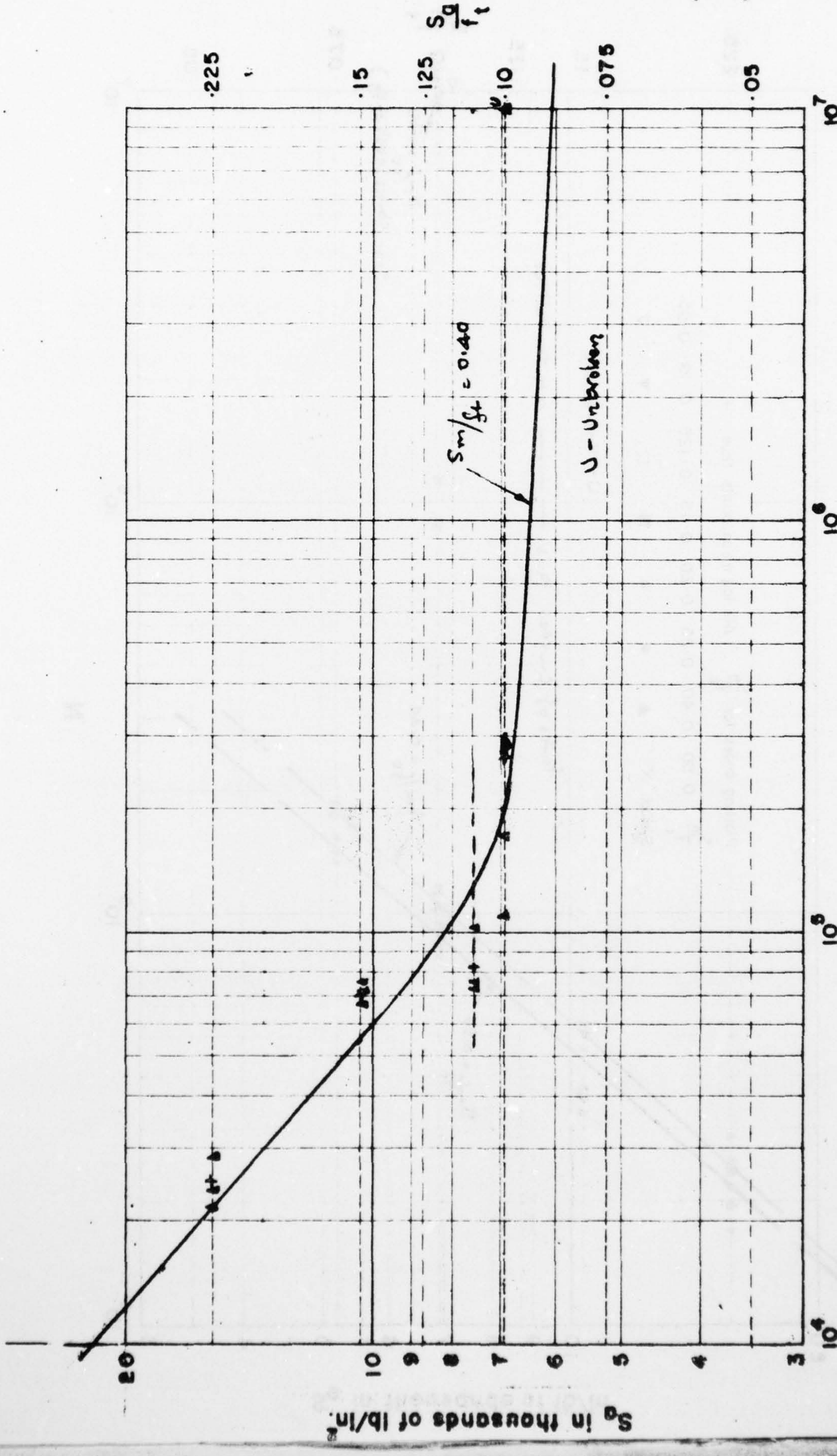


FIG. C.1(a) LARGE SPECIMENS – TYPE 1A½ ($d/D = 1/4$)

UNFILLED HOLE $S_m/f_{tu} = 0.40$ (ONLY) Ref: Table C.1



86 FIG C.2 LARGE SPECIMENS TYPE 1.A ½ ($a/D = 1/4$)

PUSH FIT PIN - PIN UNLOADED

S_m/f_t = 0.50, 0.40 & 0.15.

Ref: TABLE C.2

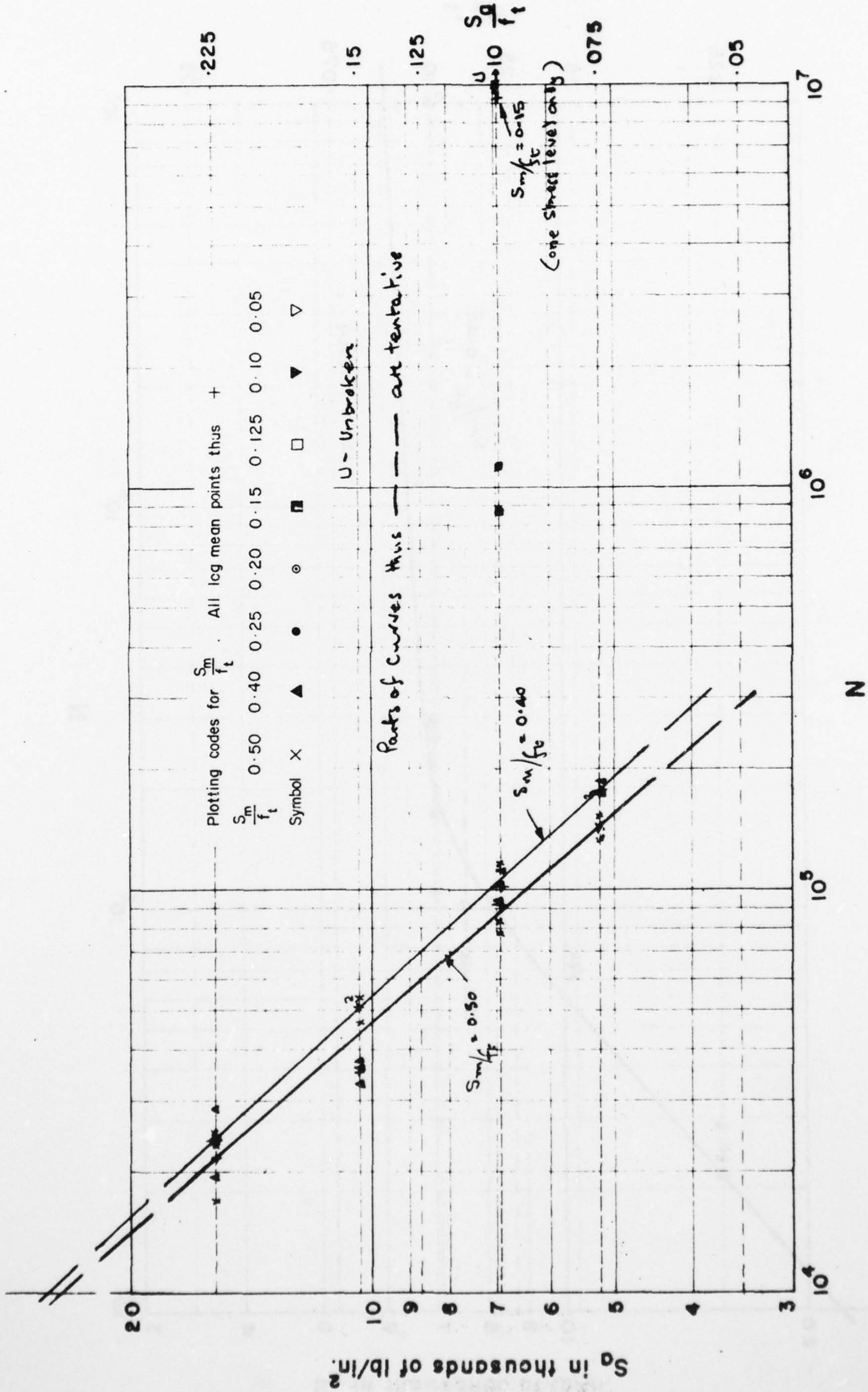


FIG. C.3 LARGE SPECIMENS TYPE 1. A ½ (a/D = ¼)

0.4% INTERFERENCE FIT PIN - PIN UNLOADED

Ref: TABLE C.3

S_m/f_t = 0.50, 0.40 & 0.25

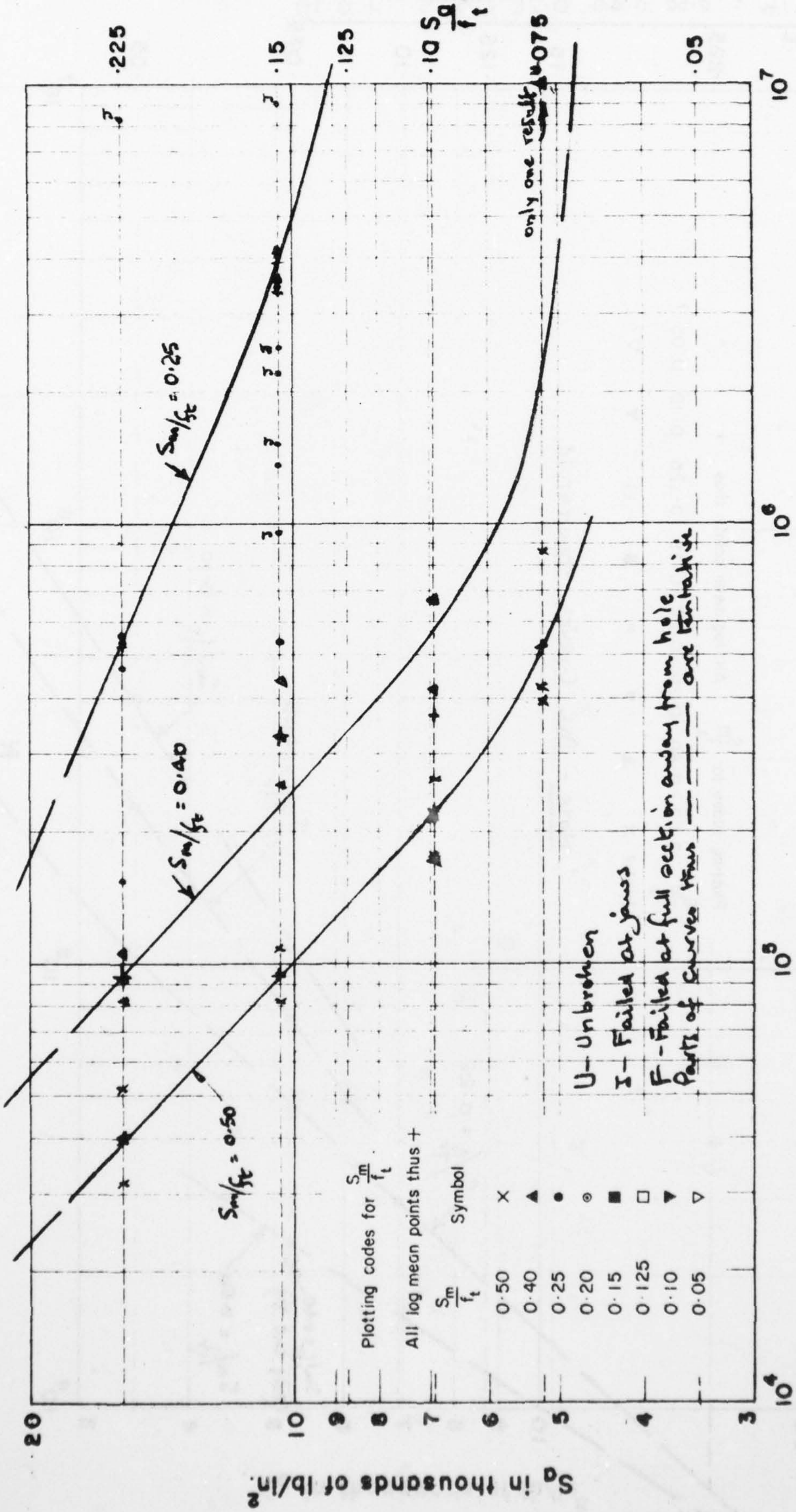


 FIG C.4 LARGE SPECIMENS TYPE I. B. 1/2 ($a/D = 1/4$)

LOOSE FIT PIN – PIN LOADED

Ref: TABLE C.4

S_m/f_t = 0.50, 0.40, 0.25, 0.15, & 0.10

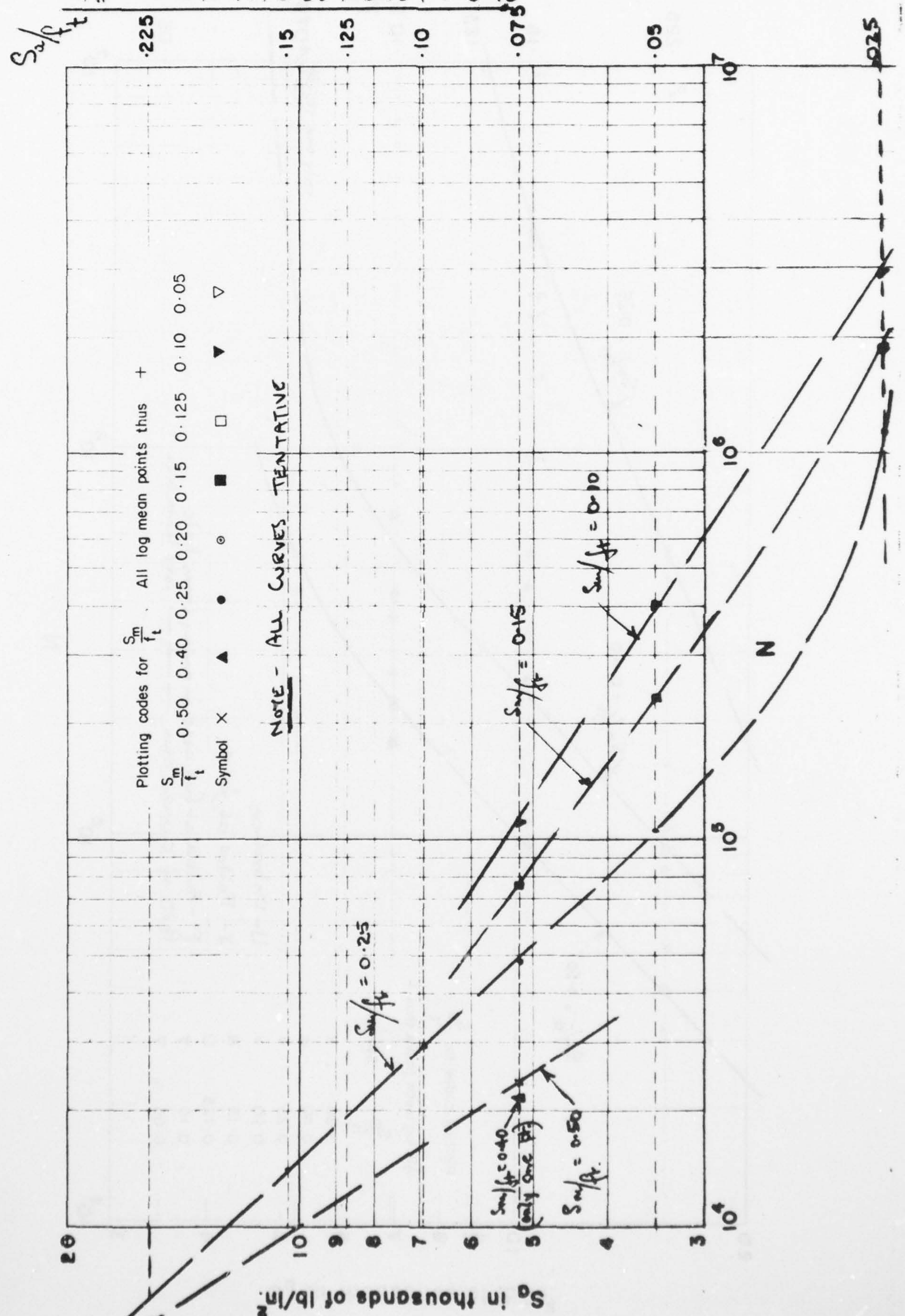
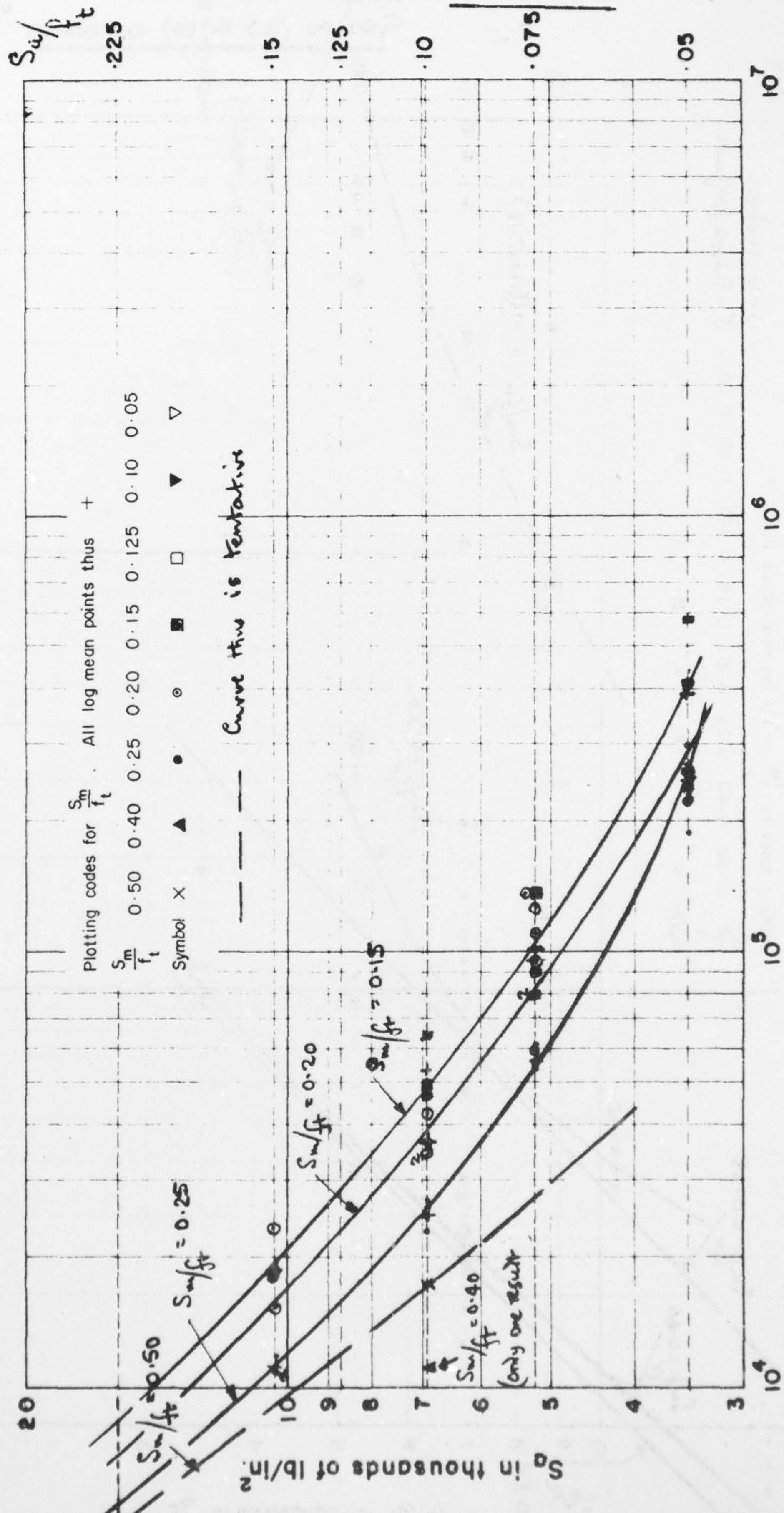


FIG C.5 LARGE SPECIMENS TYPE 1.B.½ (a/D = ¼)

PUSH FIT PIN - PIN LOADED S_m/f_t = 0.5, 0.4, 0.25, 0.2 and 0.15 Ref. TABLE C.5



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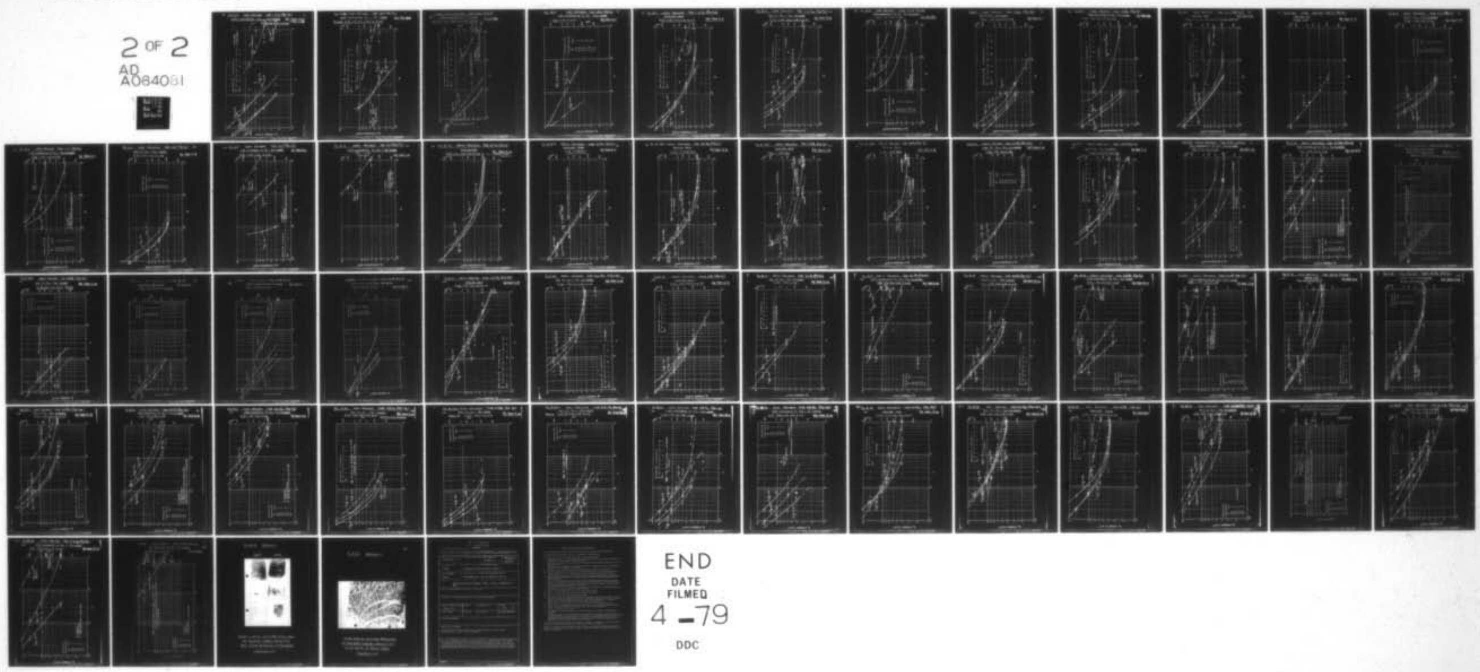

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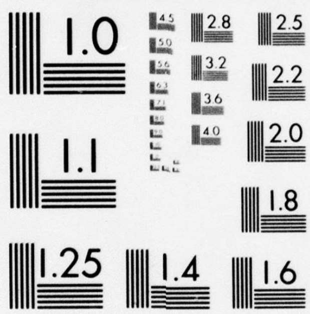

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90 FIG. C.6 LARGE SPECIMENS TYPE 1. B. ½ (a/D = ¼)

0.4% INTERFERENCE FIT. — PIN LOADED

Ref. TABLES & FIGS. C.6(a) C.6(b)

GROUPS (a) & (b) COMBINED

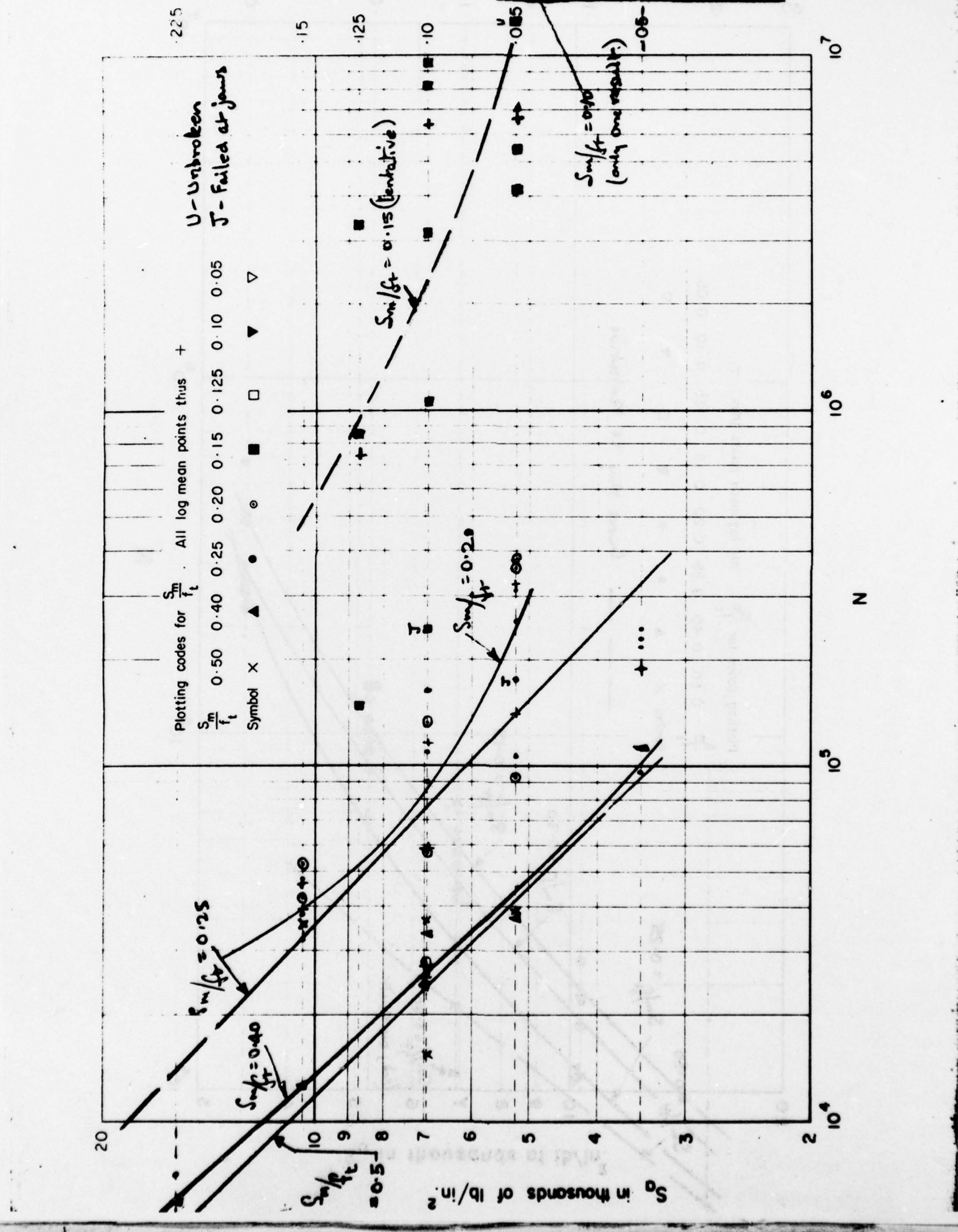


FIG C.6(a) LARGE SPECIMENS TYPE 1.B.½ (W/D = ¼)

0·4% INTERFERENCE FIT — PIN LOADED Ref. TABLE C.6(a)

Group(a) S_m/f_t = 0·50, 0·40, 0·25, 0·20 & 0·15

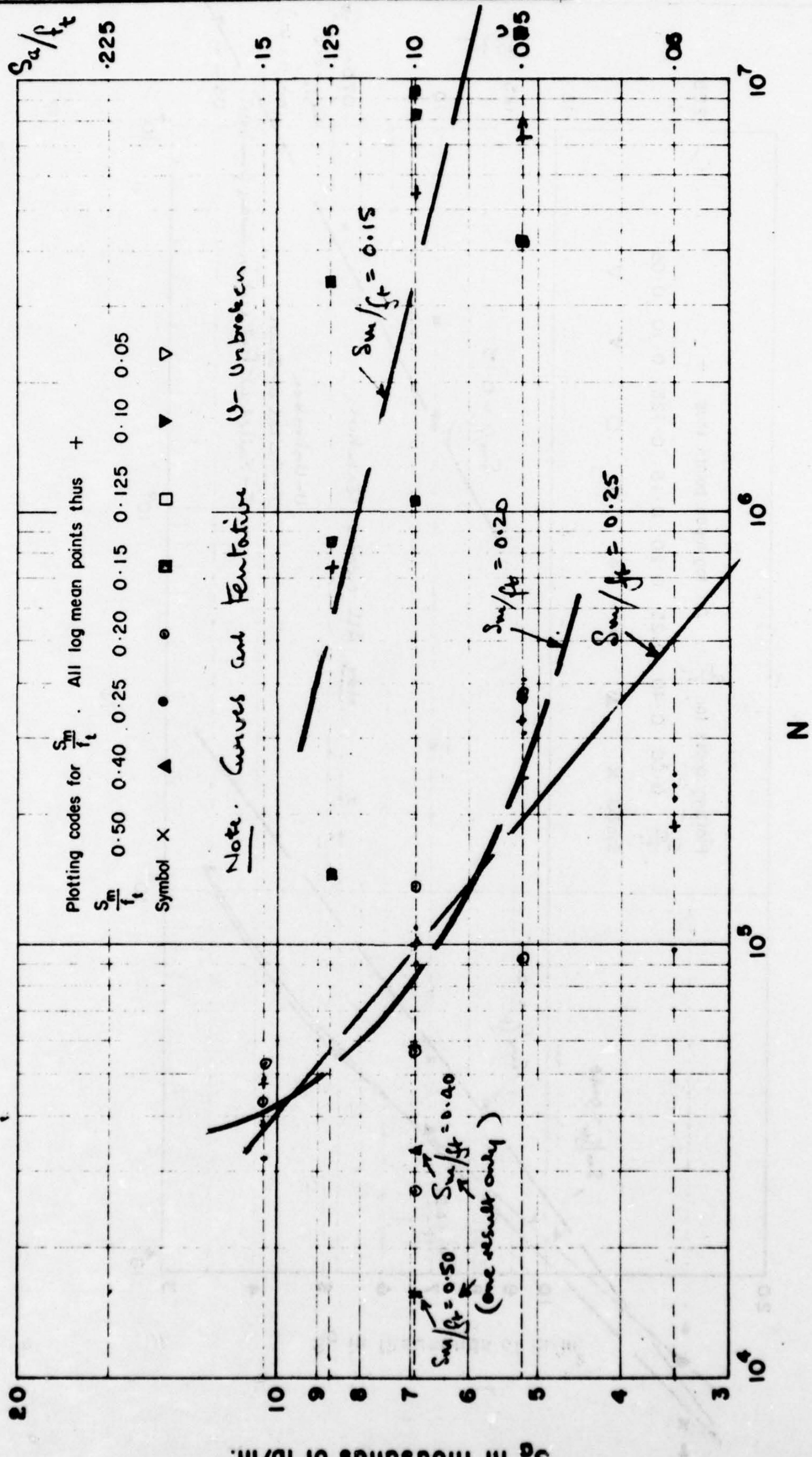


Fig. C.6(b) LARGE SPECIMENS TYPE 1.B ½ (d/D = ¼)

92. 0.4% INTERFERENCE FIT - PIN LOADED

Ref: TABLE C.6(b)

Group (b) S_m/f_t = 0.50, 0.40, 0.25, 0.15 & 0.10

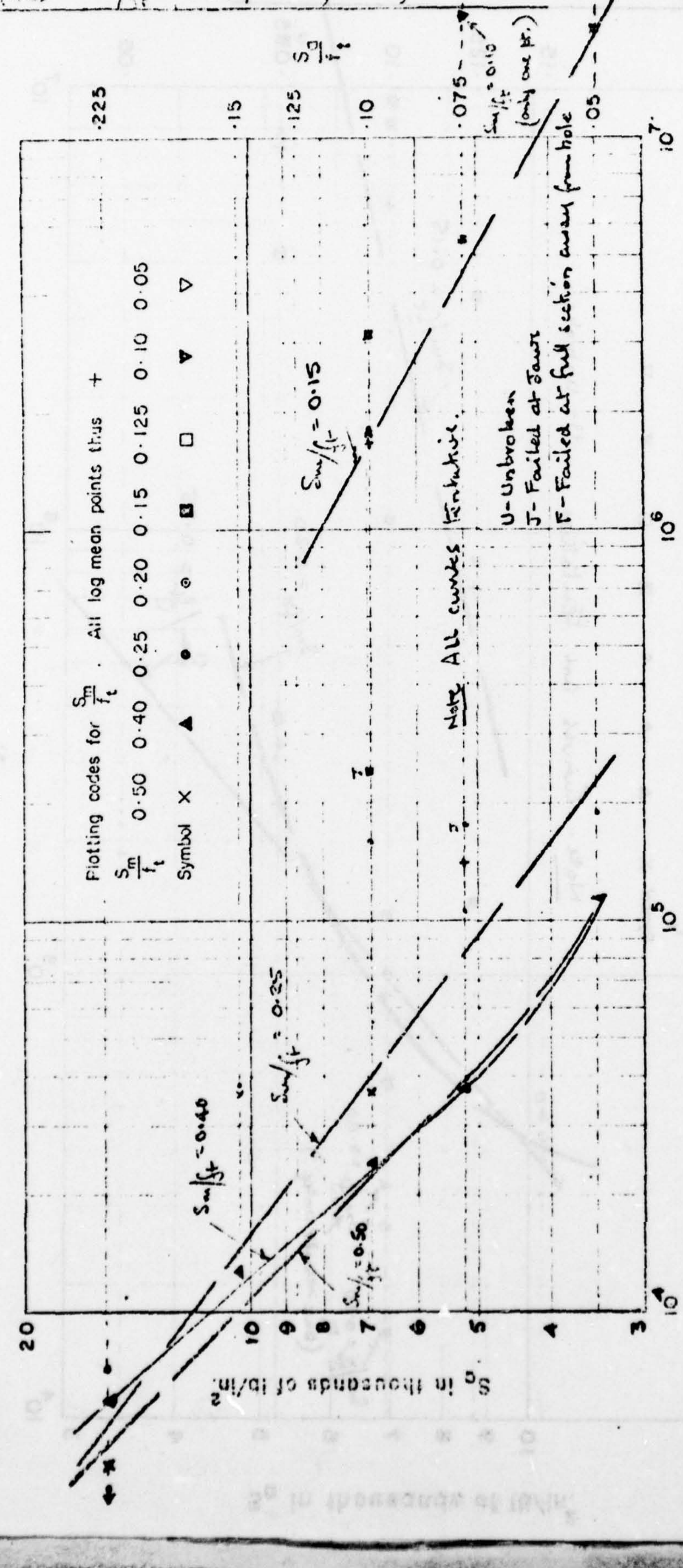
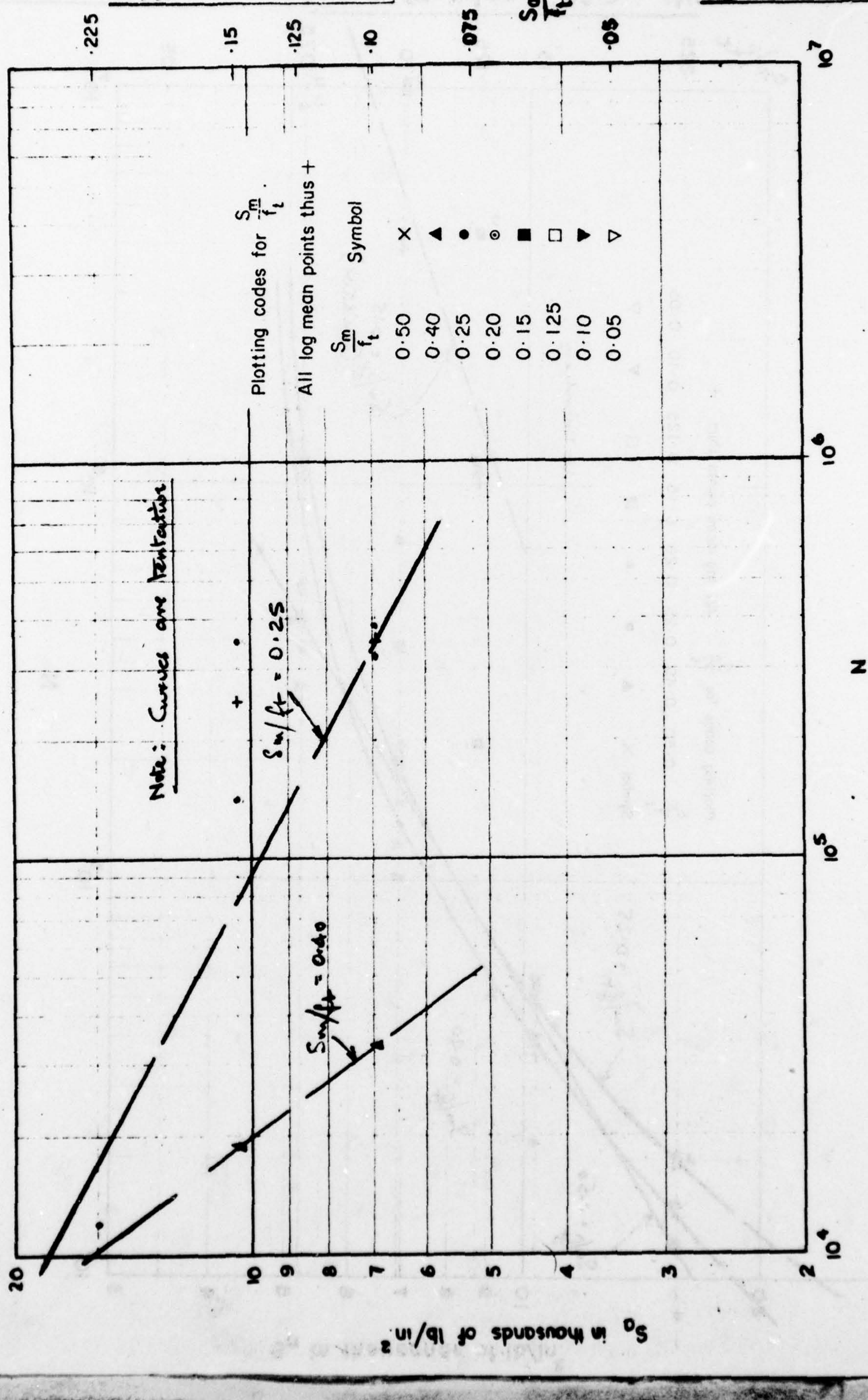


FIG. C.7 LARGE SPECIMENS TYPE 1.8½ (d/D=¼)

0.8% INTERFERENCE FIT PIN – PIN LOADED

S_m/f_t = 0.40 & 0.25 Ref. TABLE C.7

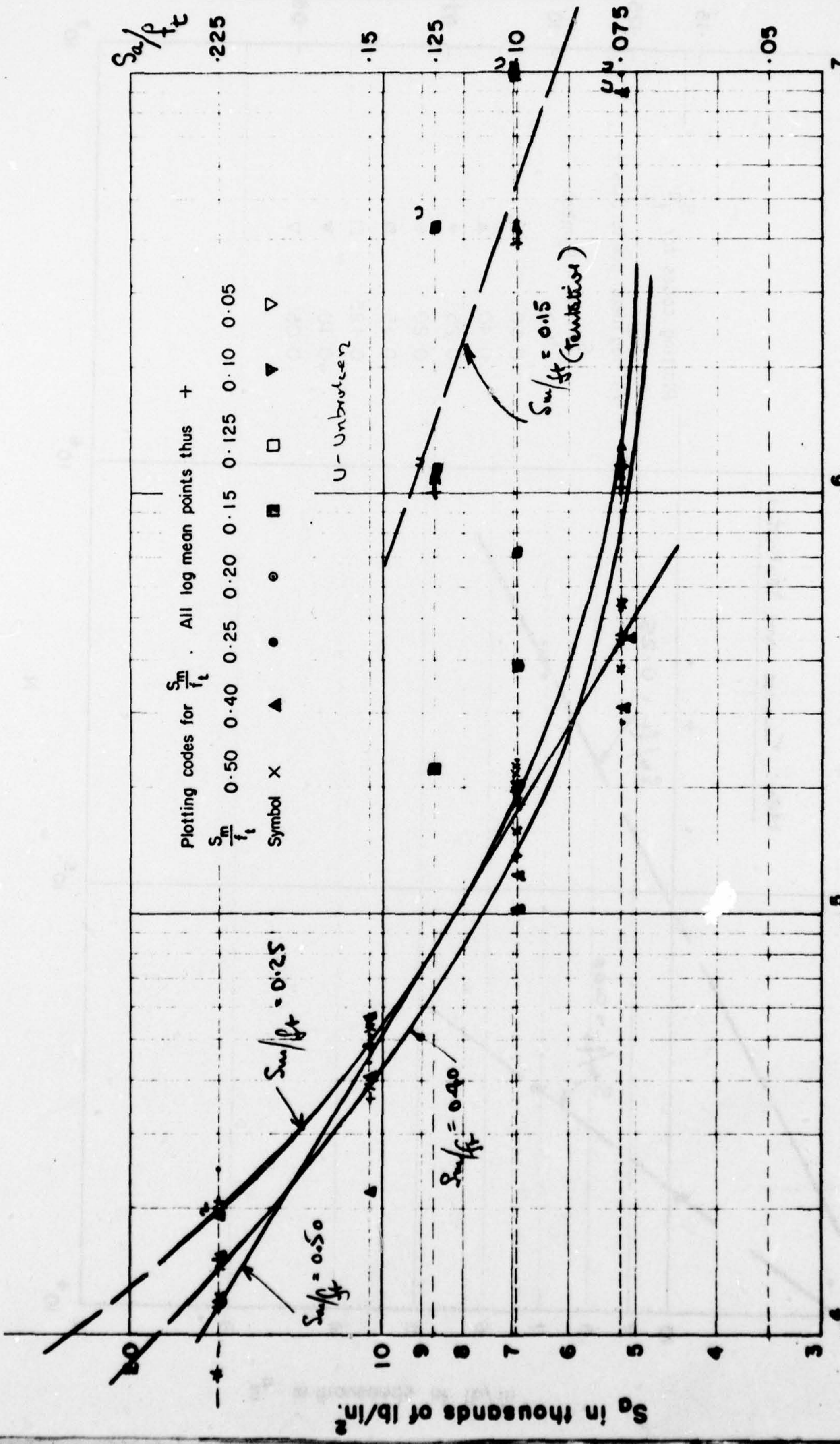


94 FIG C.8 LARGE SPECIMENS TYPE 1. C. 3/4 ($d/D = 3/8$)

UNFILLED HOLE

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

Ref. TABLE C.8



F.G. C.9 LARGE SPECIMENS TYPE 1. C. $3/4$ ($d/D = 3/8$)

PUSH FIT PIN — PIN UNLOADED

Ref. TABLE C.9

S_m/f_t = 0.50, 0.40, 0.25 & 0.15.

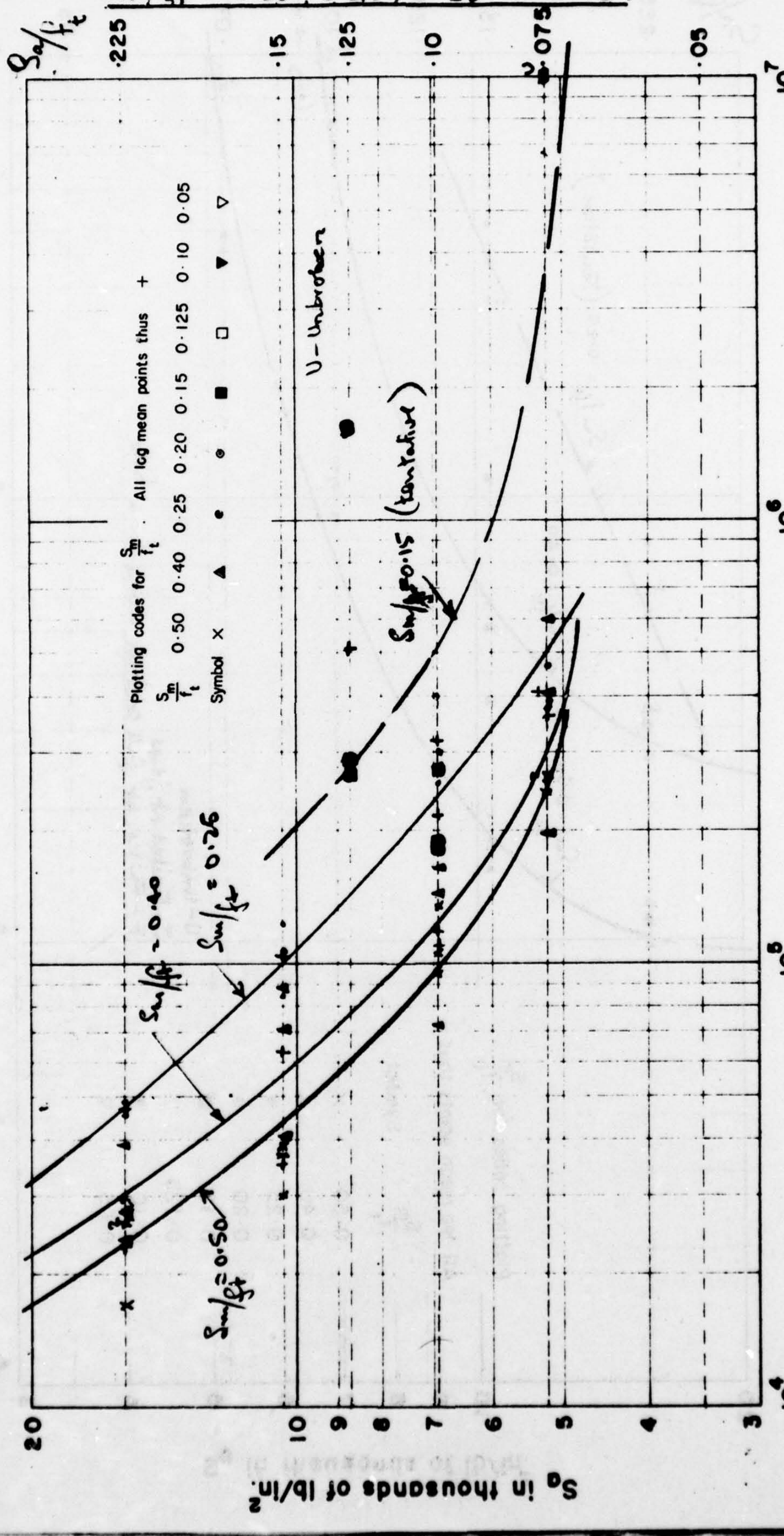


FIG. C.10 LARGE SPECIMENS TYPE 1. C. 3/4 (W/D = 3/8)

0.4% INTERFERENCE FIT PIN – PIN UNLOADED

S_m/f_t = 0.50, 0.40 & 0.25

Ref: TABLE C.10

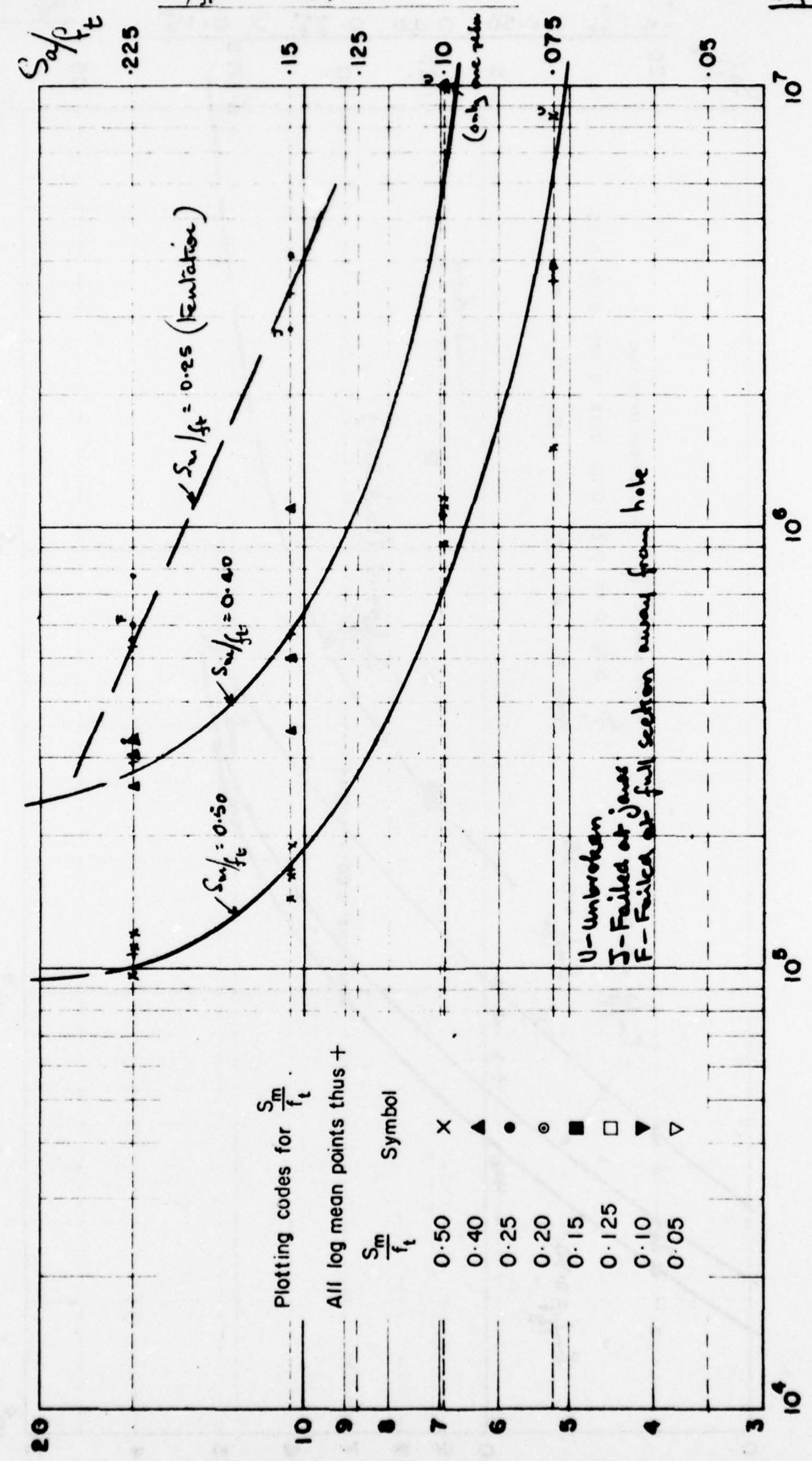


FIG C.11 LARGE SPECIMENS TYPE 1.D.3/4 (d/D = 3/8)

PUSH FIT PIN — PIN LOADED

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

Ref. TABLE C.11

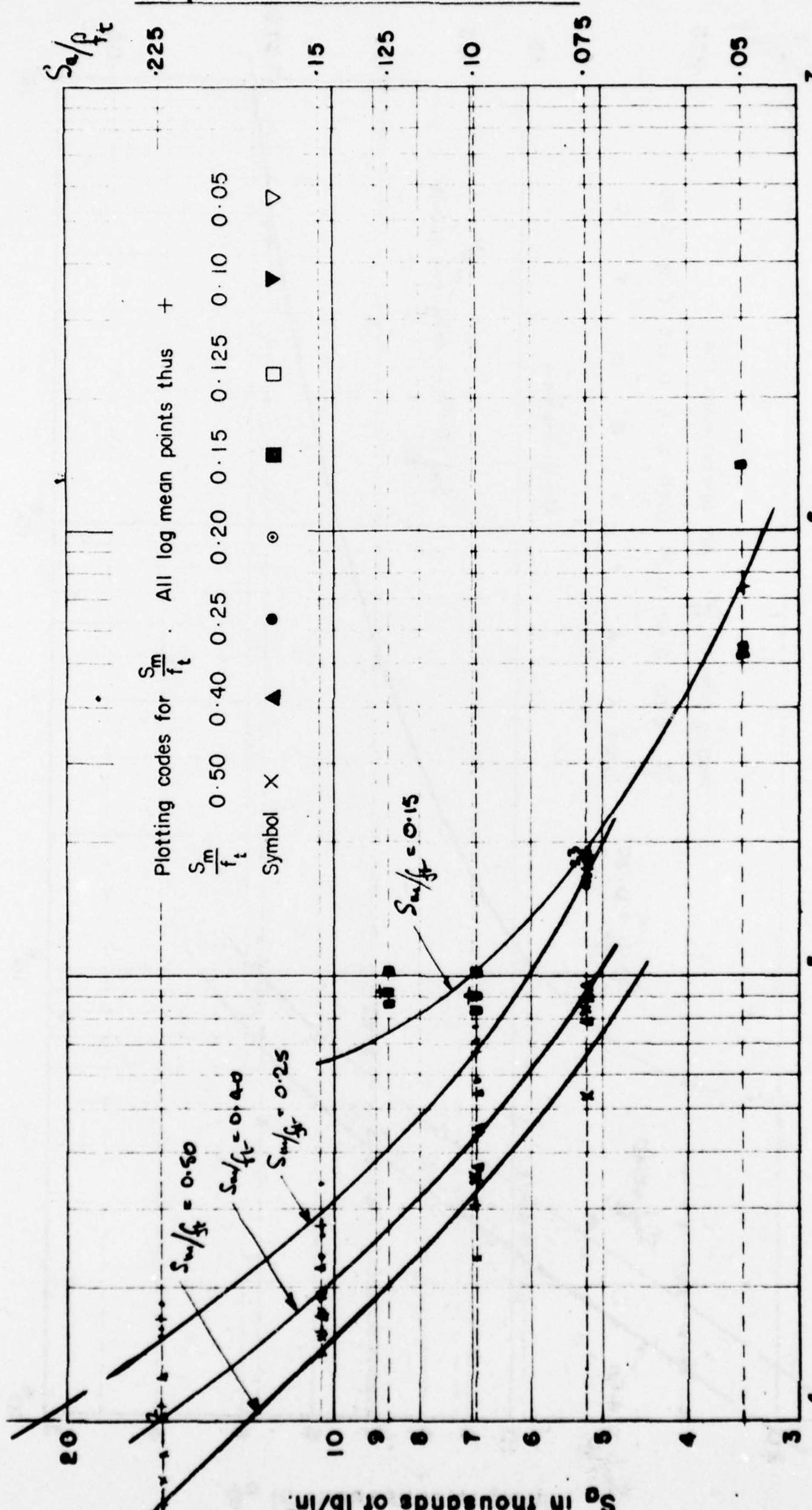


FIG C.12 LARGE SPECIMENS TYPE 1.D.3/4. ($d/D = 3/8$)

0.4% INTERFERENCE FIT PIN – PIN LOADED

Ref: TABLE C.

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

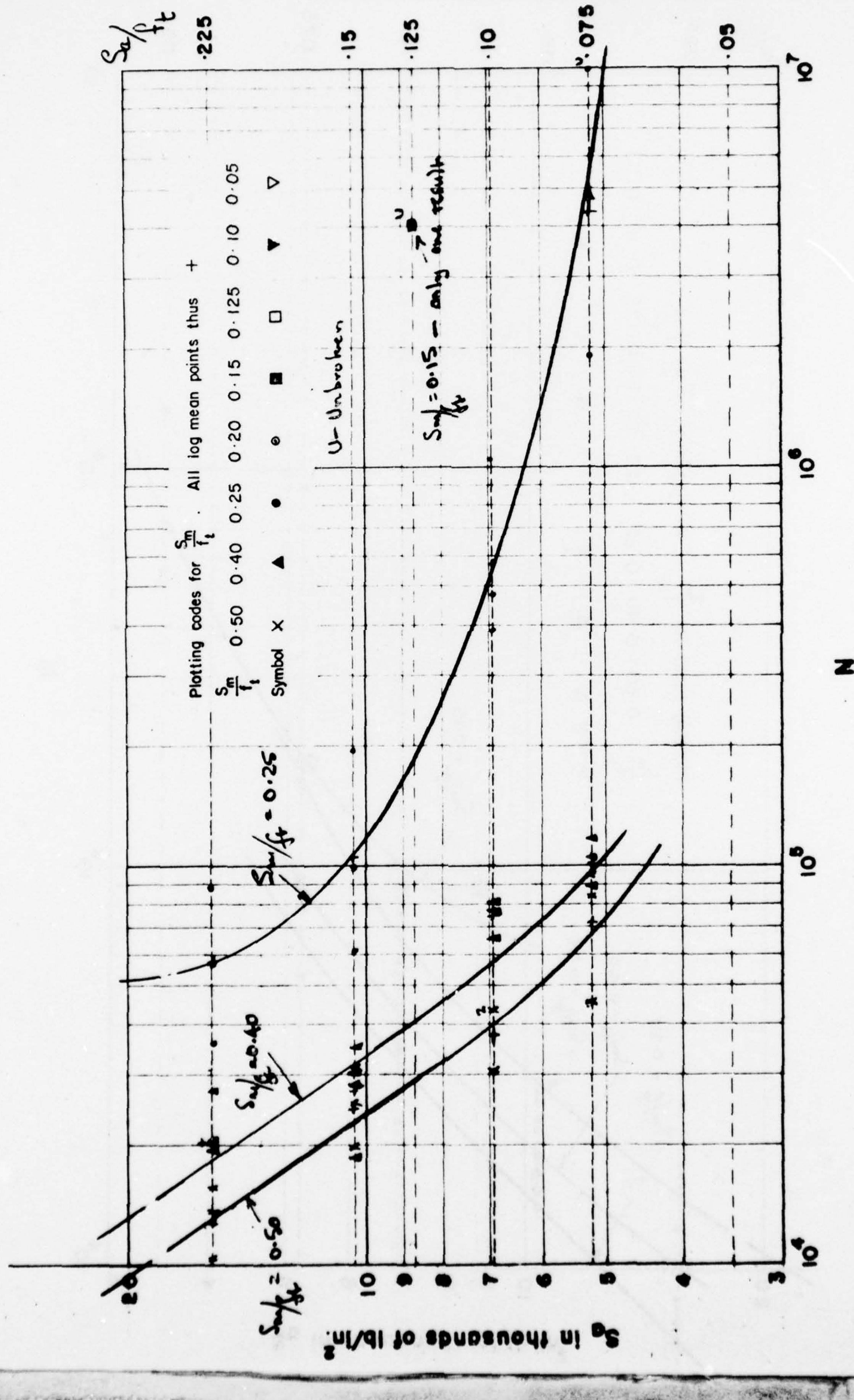


FIG C.13 LARGE SPECIMENS TYPE 1.C.1 ($a/D = 1/2$)

UNFILLED HOLE

Ref: TABLE C.13

$S_m/f_t = 0{\cdot}50,\ 0{\cdot}40,\ 0{\cdot}25,\ \&\ 0{\cdot}15$ (0·40 from Fig C.13(a))

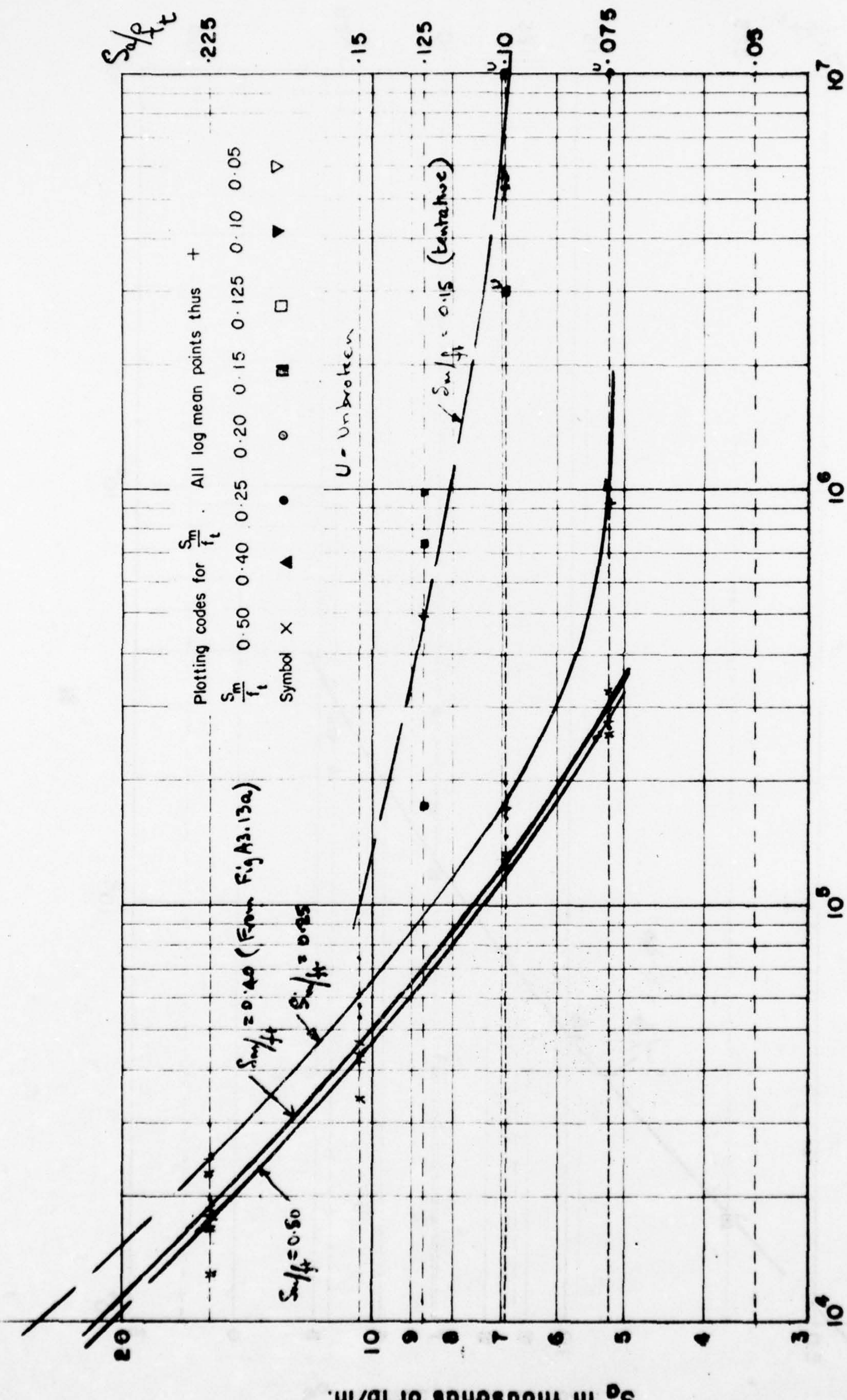


FIG. C.13(a) LARGE SPECIMENS TYPE I.C.1 ($d/D = 1/2$)

UNFILLED HOLE

$S_m/f_t = 0.40$

Ref TABLE C.13.

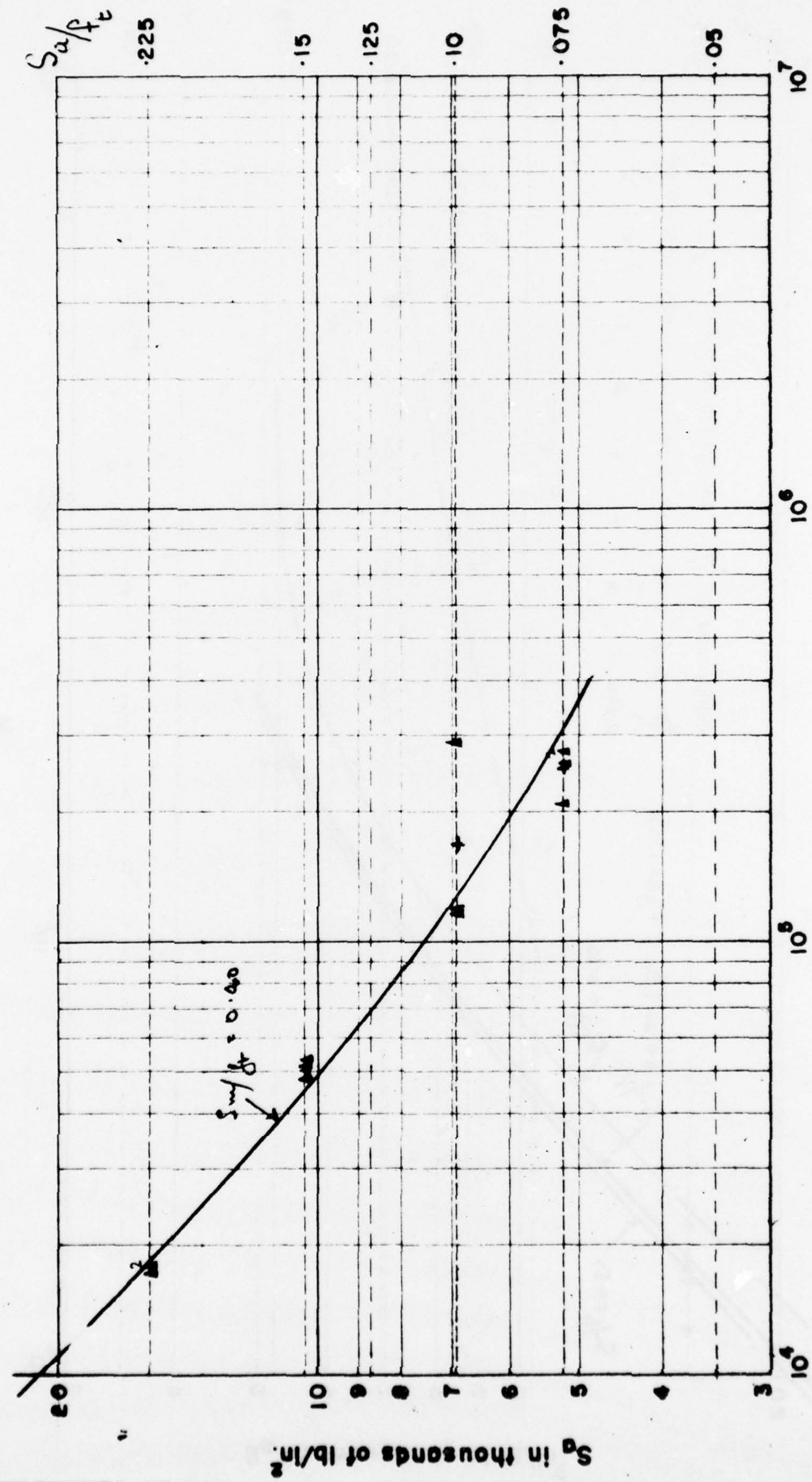


FIG. C.14 LARGE SPECIMENS TYPE 1.C.1 (d/D = 1/2)

PUSH FIT PIN – PIN UNLOADED

S_m/f_t = 0·50, 0·40 & 0·25

Ref. TABLE C.14

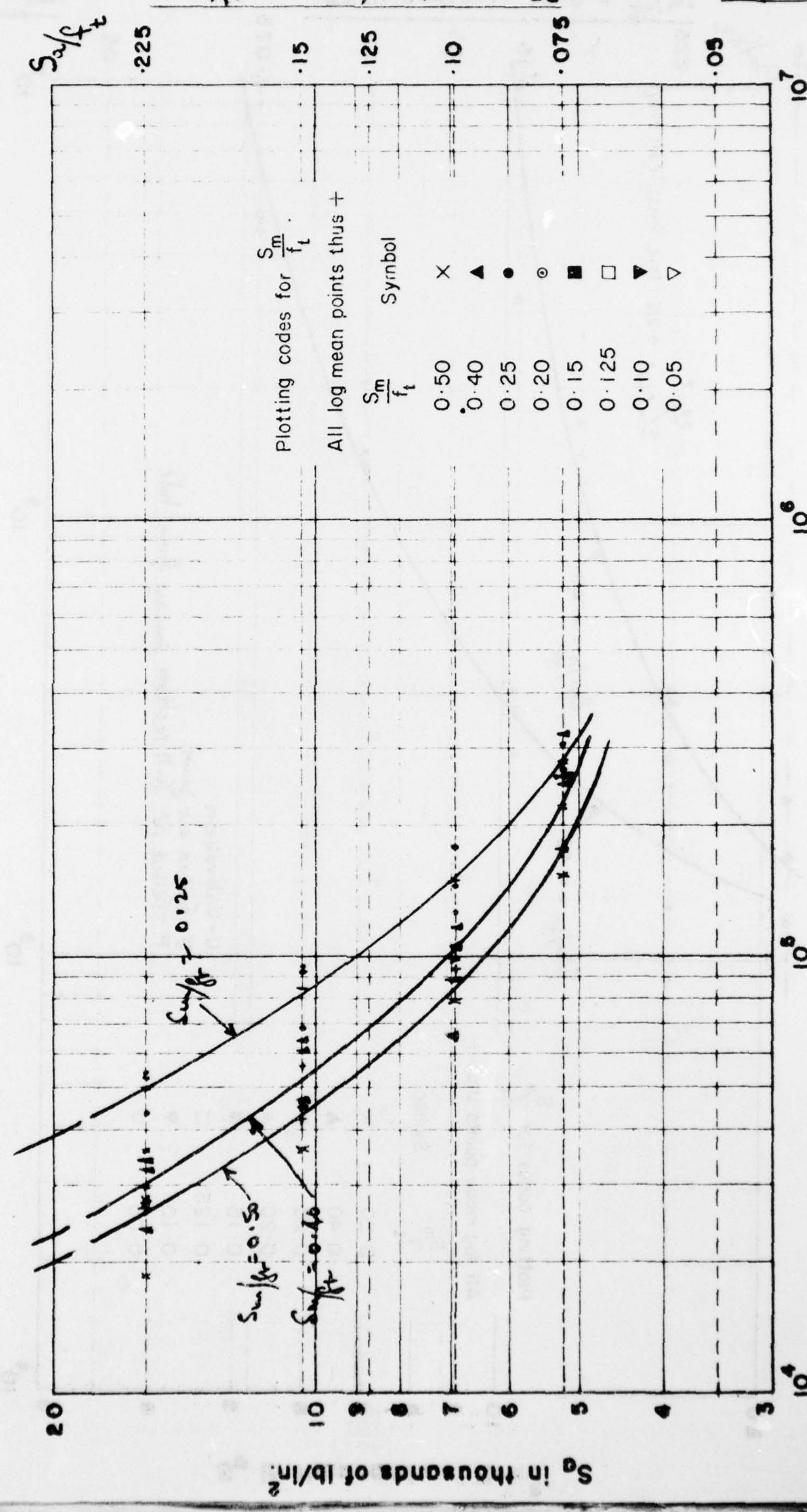


FIG. C.15 LARGE SPECIMENS TYPE 1.C.1. ($a/D = 1/2$)

0.4% INTERFERENCE FIT PIN — PIN UNLOADED

$S_m/f_t = 0.50,\ 0.40\ \&\ 0.25$

Ref. TABLE C.15

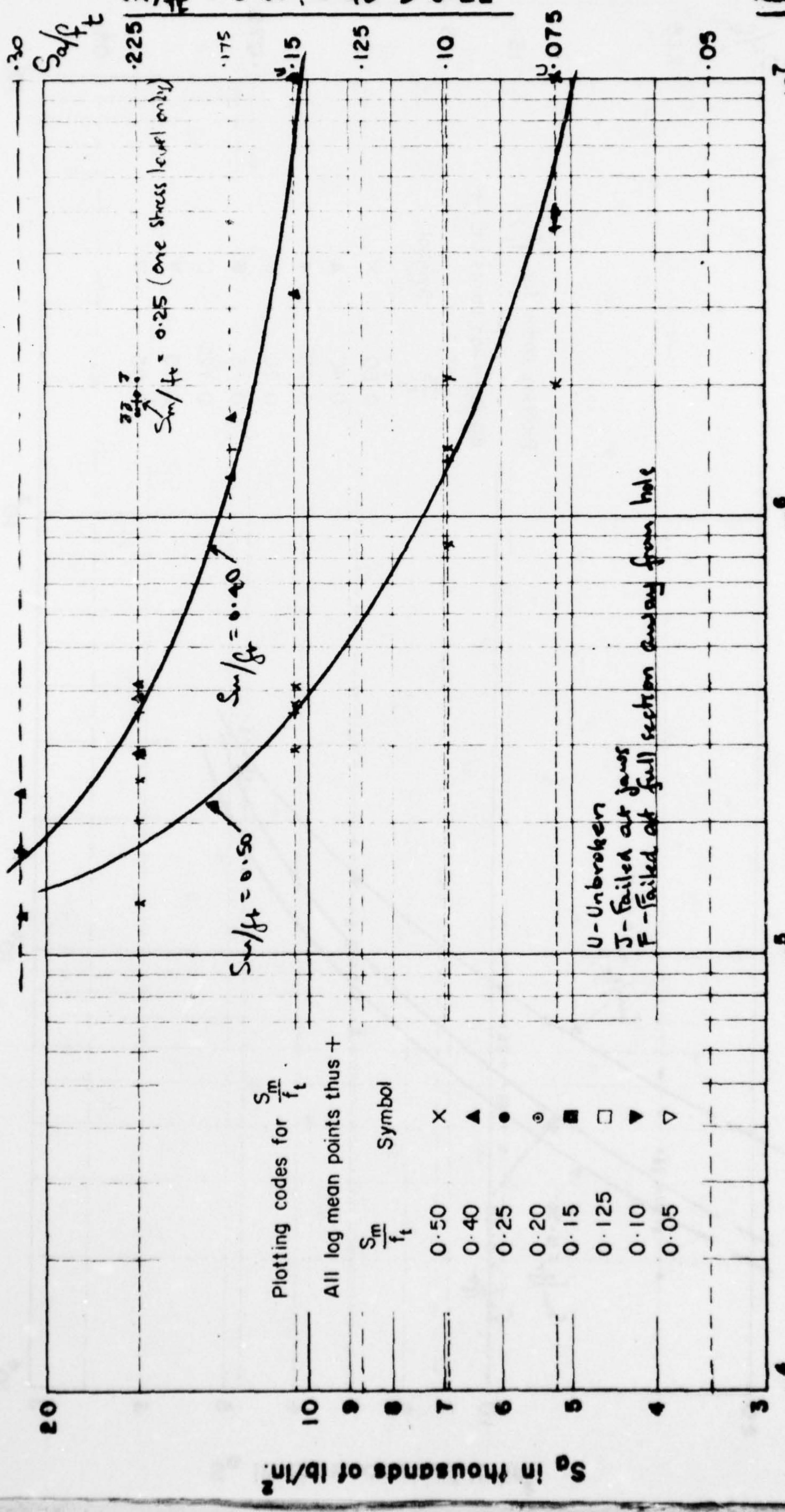


FIG. C.16 LARGE SPECIMENS TYPE 1.D.1 ($d/b = 1/2$)

PUSH FIT PIN — PIN LOADED

S_m/f_t = 0·50, 0·40 & 0·25

Ref: TABLE C.16

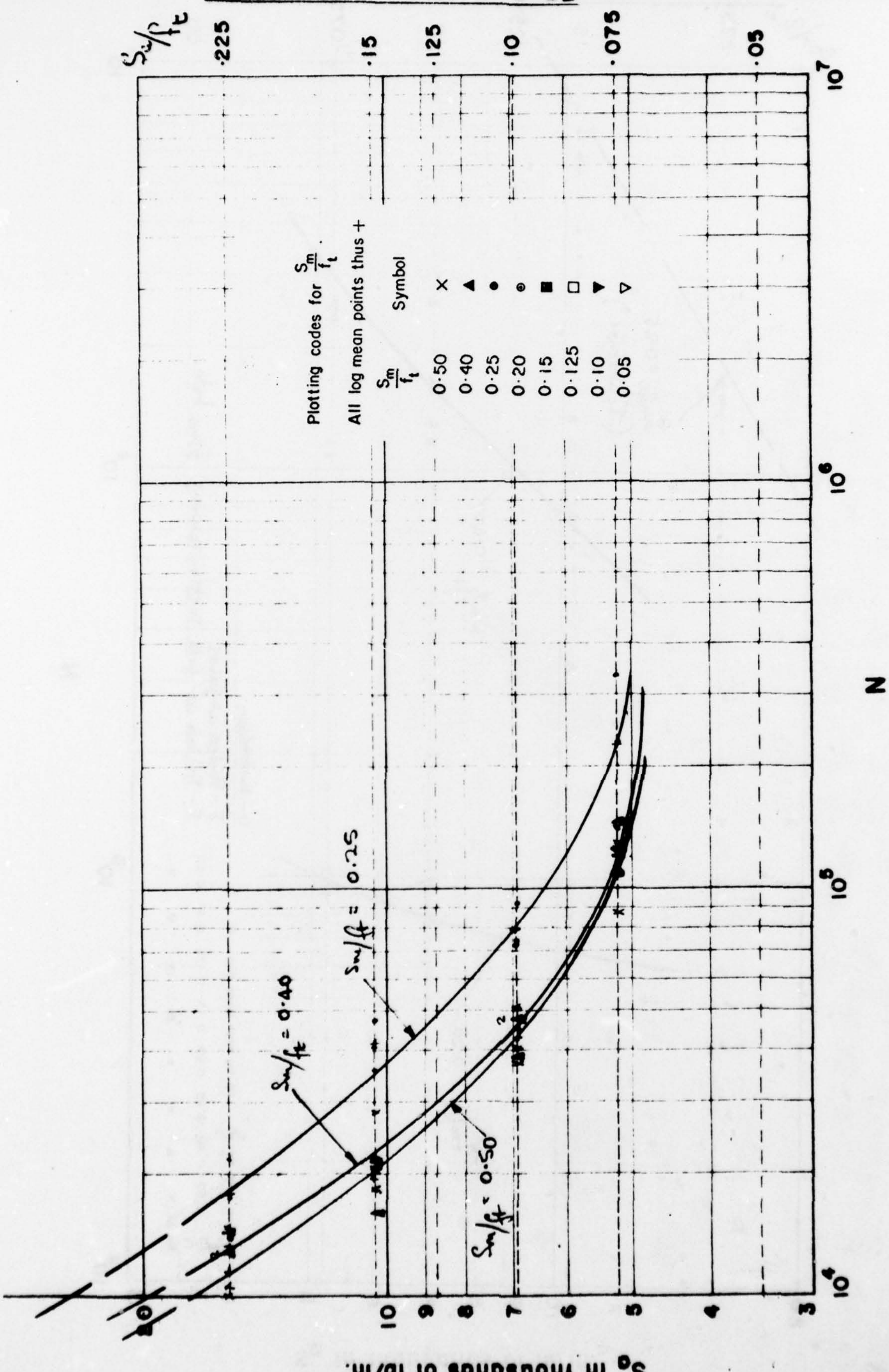


FIG C.17 LARGE SPECIMENS TYPE 1.D.1 ($d/D = 1/2$)

0.4% INTERFERENCE FIT PIN – PIN LOADED

Ref. TABLE C.17

S_m/f_t = 0.50, 0.40, & 0.25

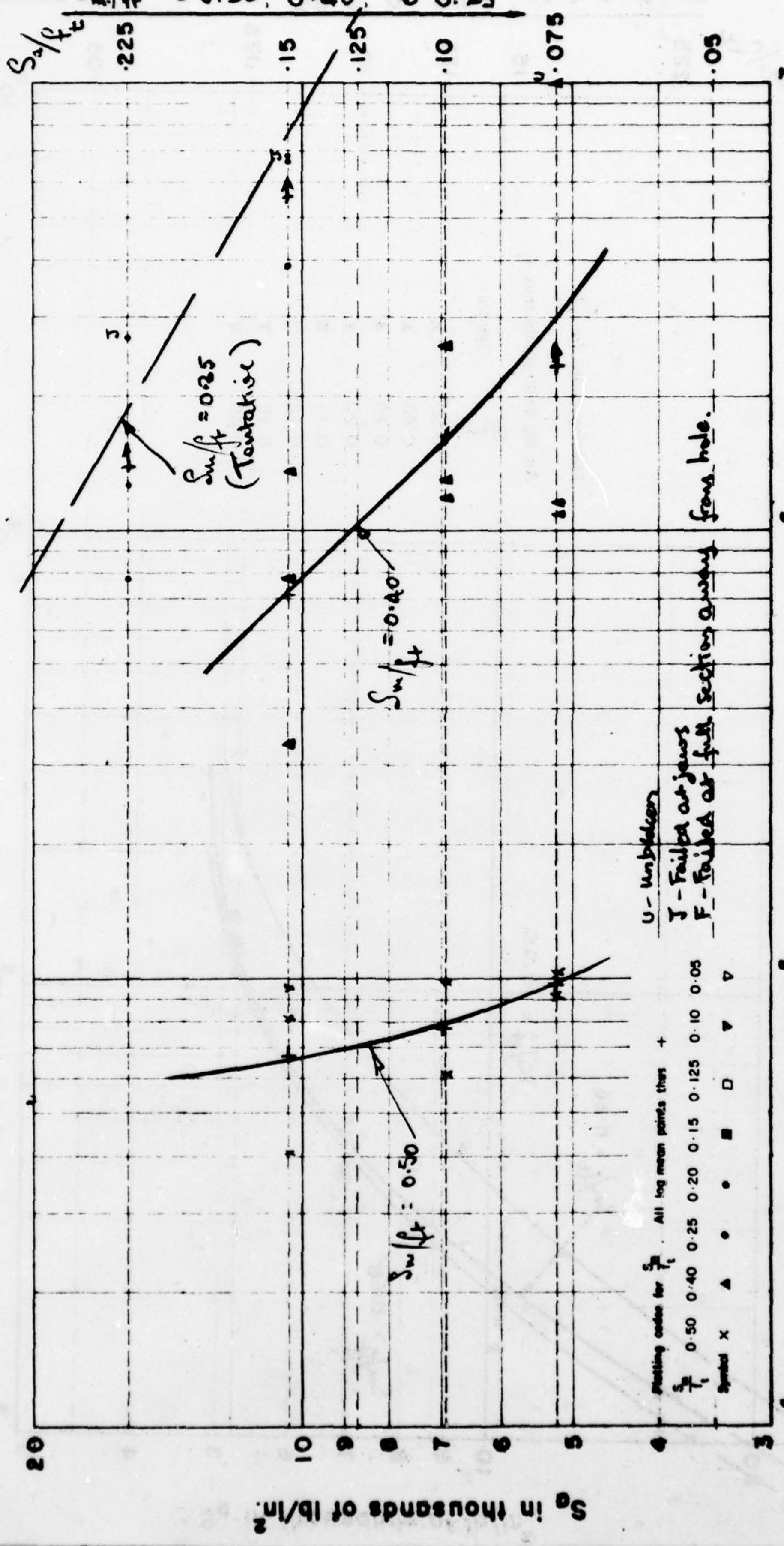


FIG C.18 LARGE SPECIMENS TYPE 1.D.1 ($d/D = 1/2$)

0.8% INTERFERENCE FIT PIN — PIN LOADED

$S_m/f_t = 0.5$

REF TABLE C.18

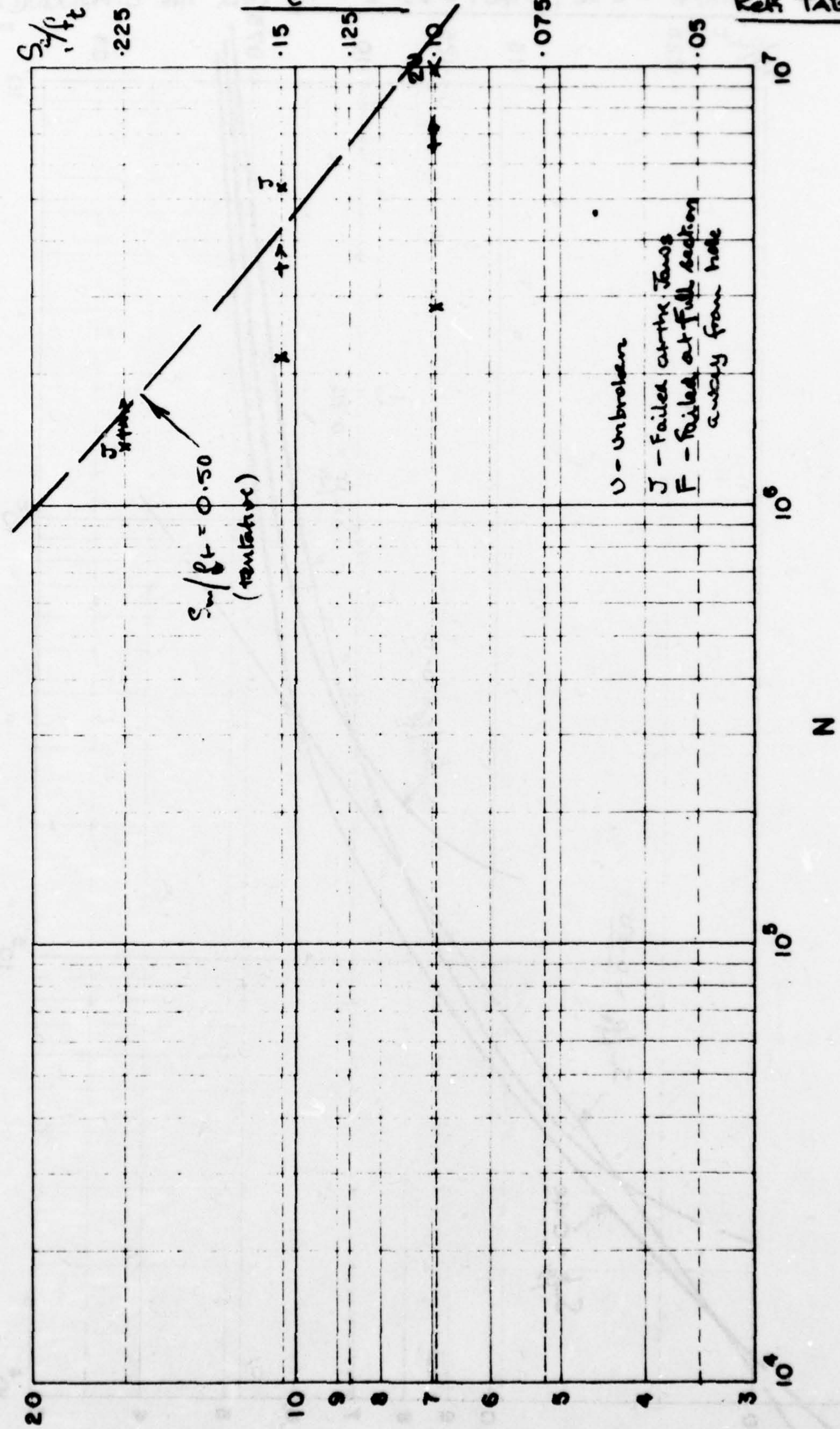


FIG. C.19 MEDIUM SPECIMENS TYPE 2.A.5/16 ($d/D = 1/2$)

UNFILLED HOLE

REF: TABLE C.19

S_m/f_t = 0.50, 0.40, 0.25 & 0.15 (from Figs. C.19(a)(b)(c) and (d) respectively).

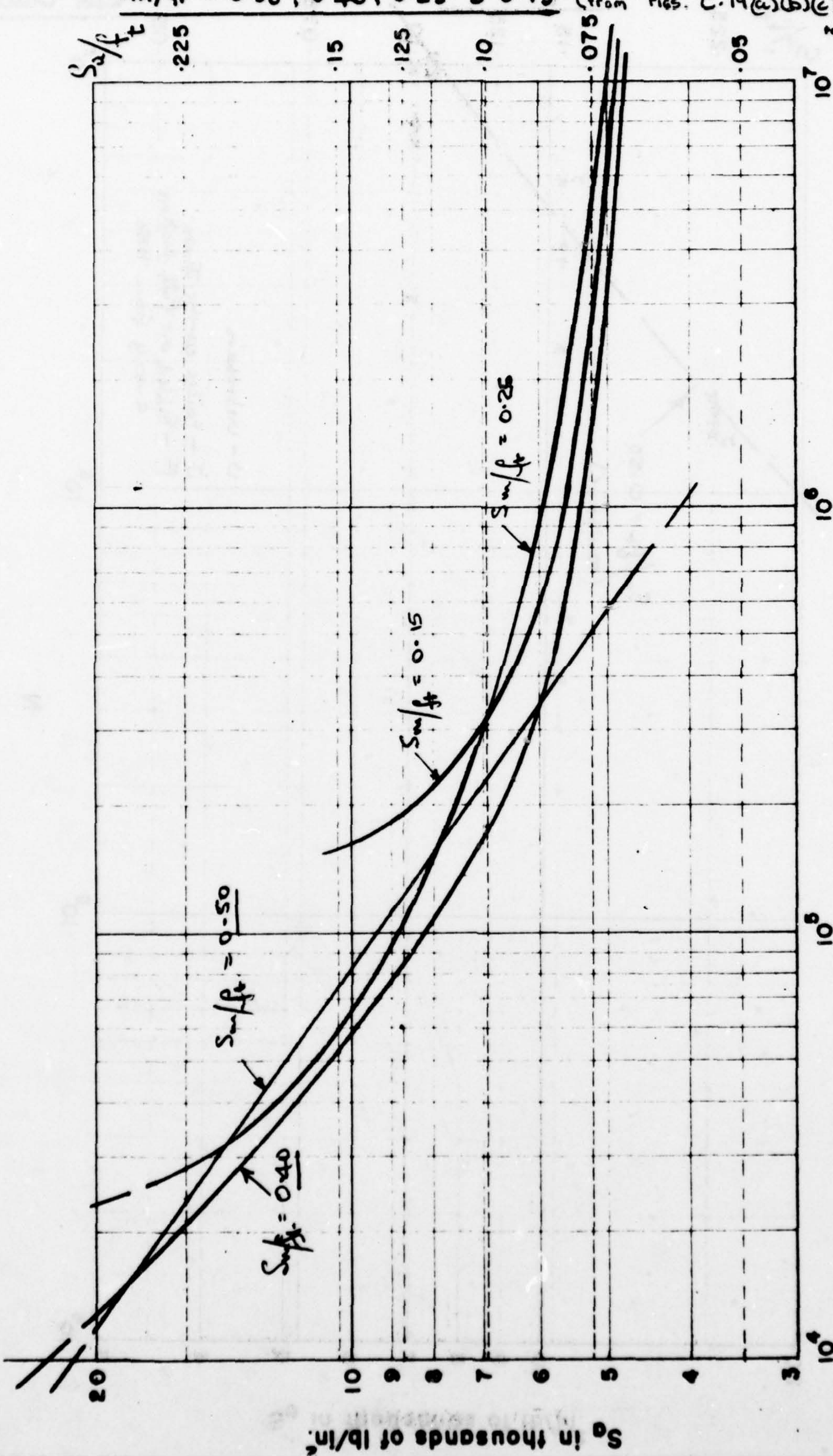
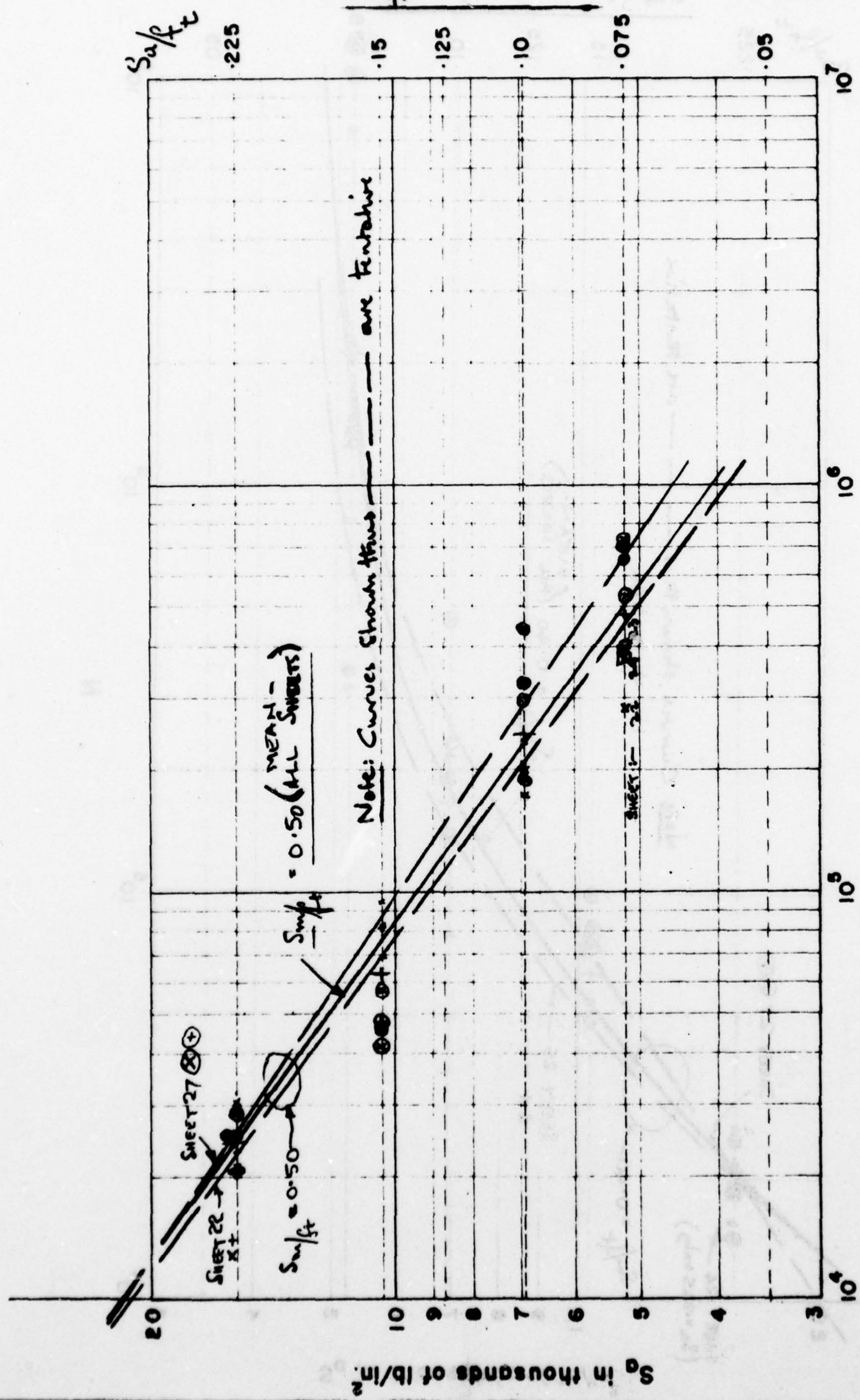


Fig. C.19(a) MEDIUM SPECIMENS TYPE 2A.5/16 ($d/D = 1/4$)

UNFILLED HOLE

$S_m/f_t = 0.50$ ONLY

Ref. TABLE C.19



108 Fig. C.19(b) MEDIUM SPECIMENS TYPE 2A. 5/16 ($d/D = 1/4$)

UNFILLED HOLE

Ref. TABLE C.19

S_m/f_t = 0.40 ONLY

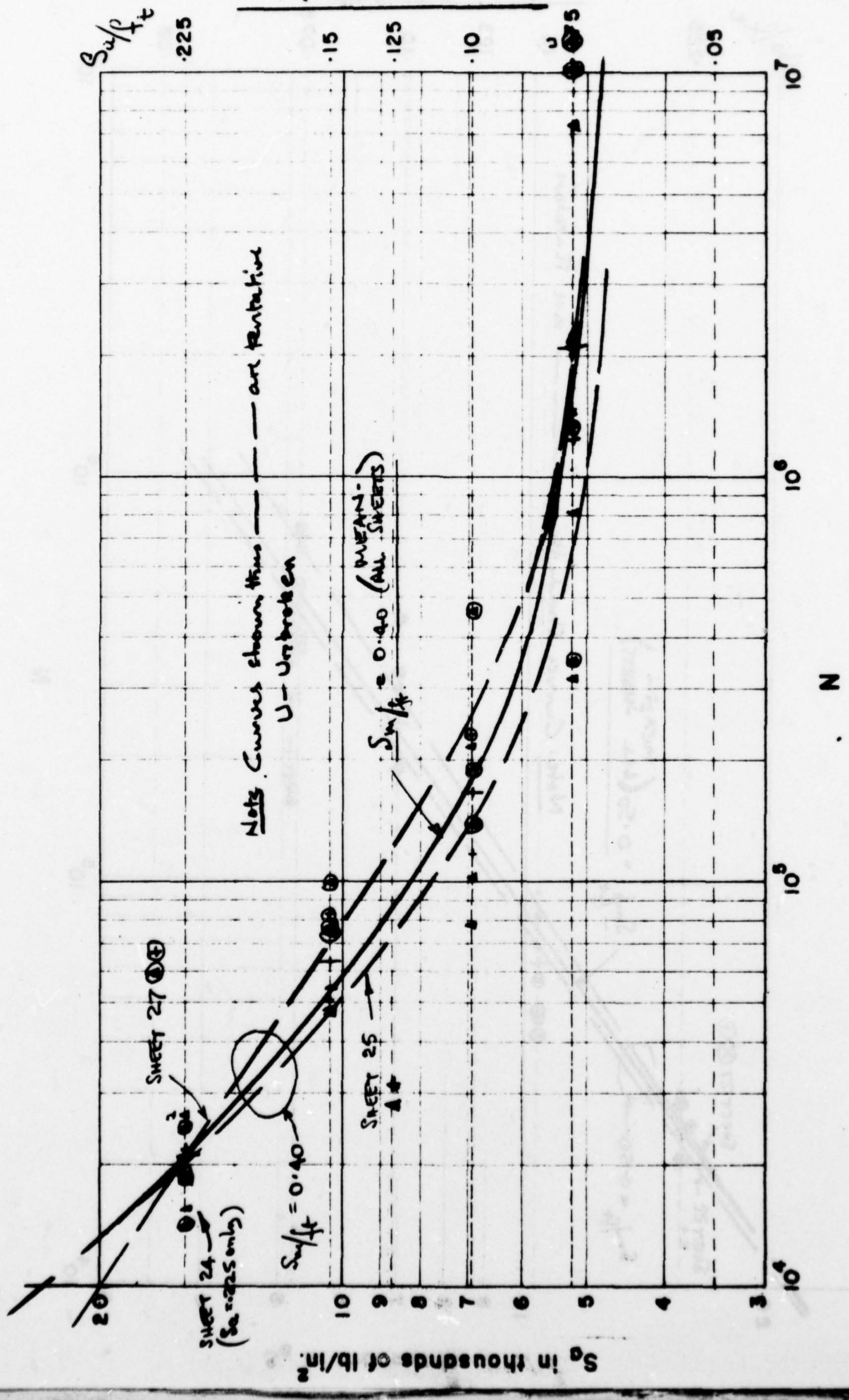
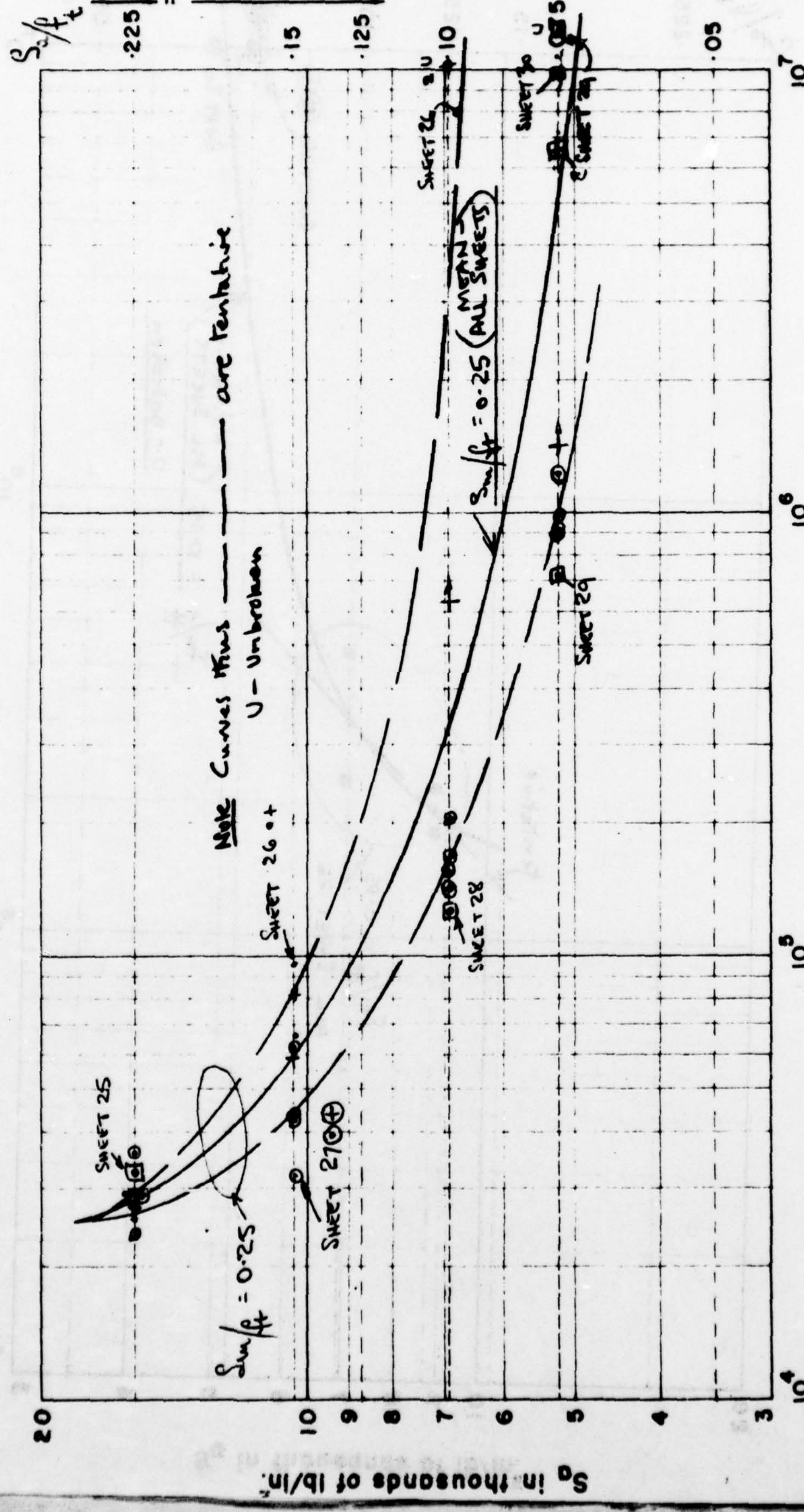


FIG. C. 19(C) MEDIUM SPECIMENS TYPE 2.A.5/16 (d/D = 1/4)

UNFILLED HOLE

Ref: TABLE C.19

S_m/f_t = 0·25 ONLY



110

FIG C.19 (d) MEDIUM SPECIMENS TYPE 2A.5/16 (a/D = 1/4)

UNFILLED HOLE

Sm/ft = 0.15 ONLY

Refs:- TABLE C.19

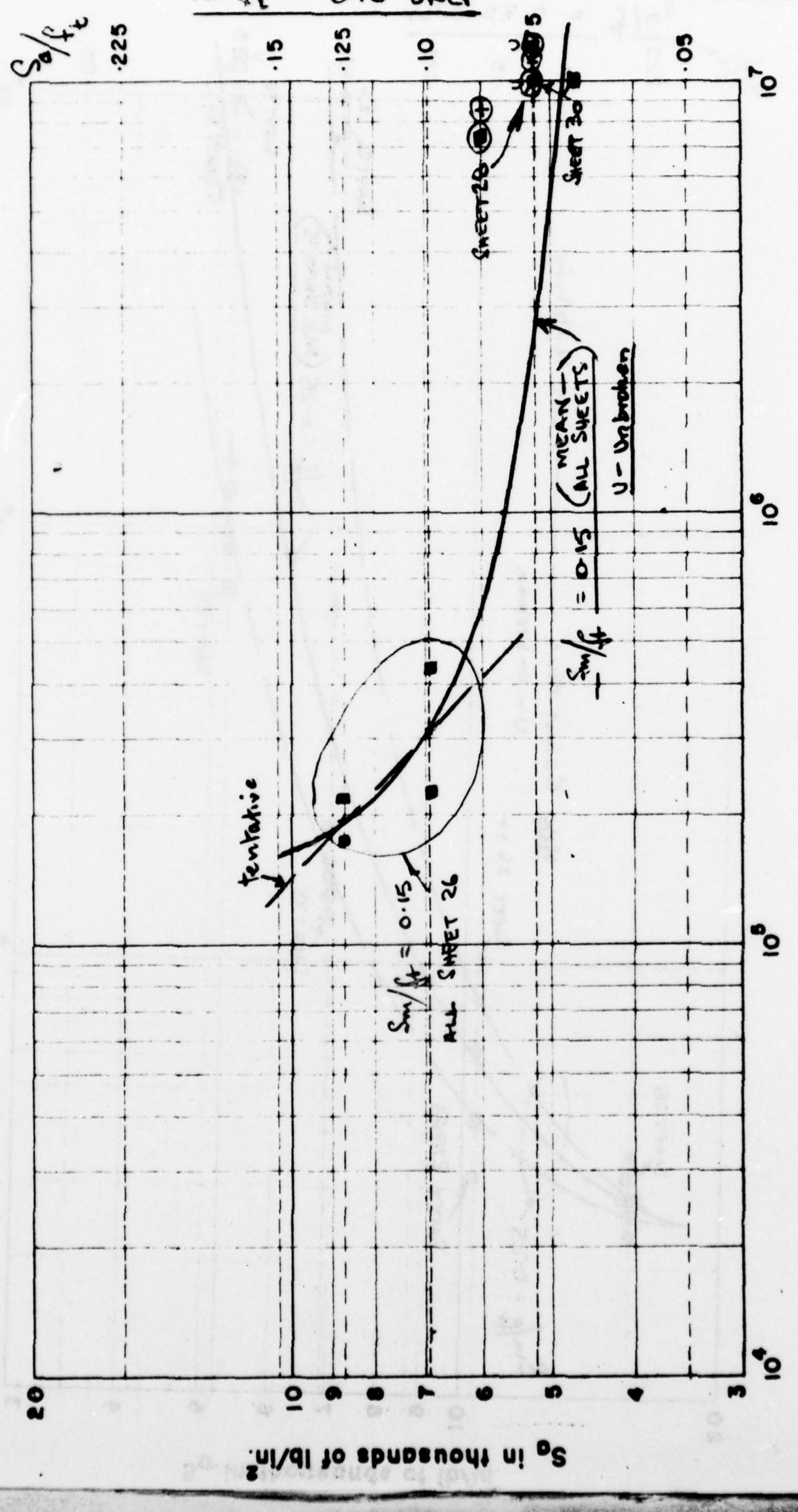


FIG. C.20 MEDIUM SPECIMENS TYPE 2A.5/16 (d/D = 1/4)

LOOSE FIT PIN – PIN UNLOADED Ref: TABLE C.20

S_m/f_t = 0.50 0.40 & 0.25

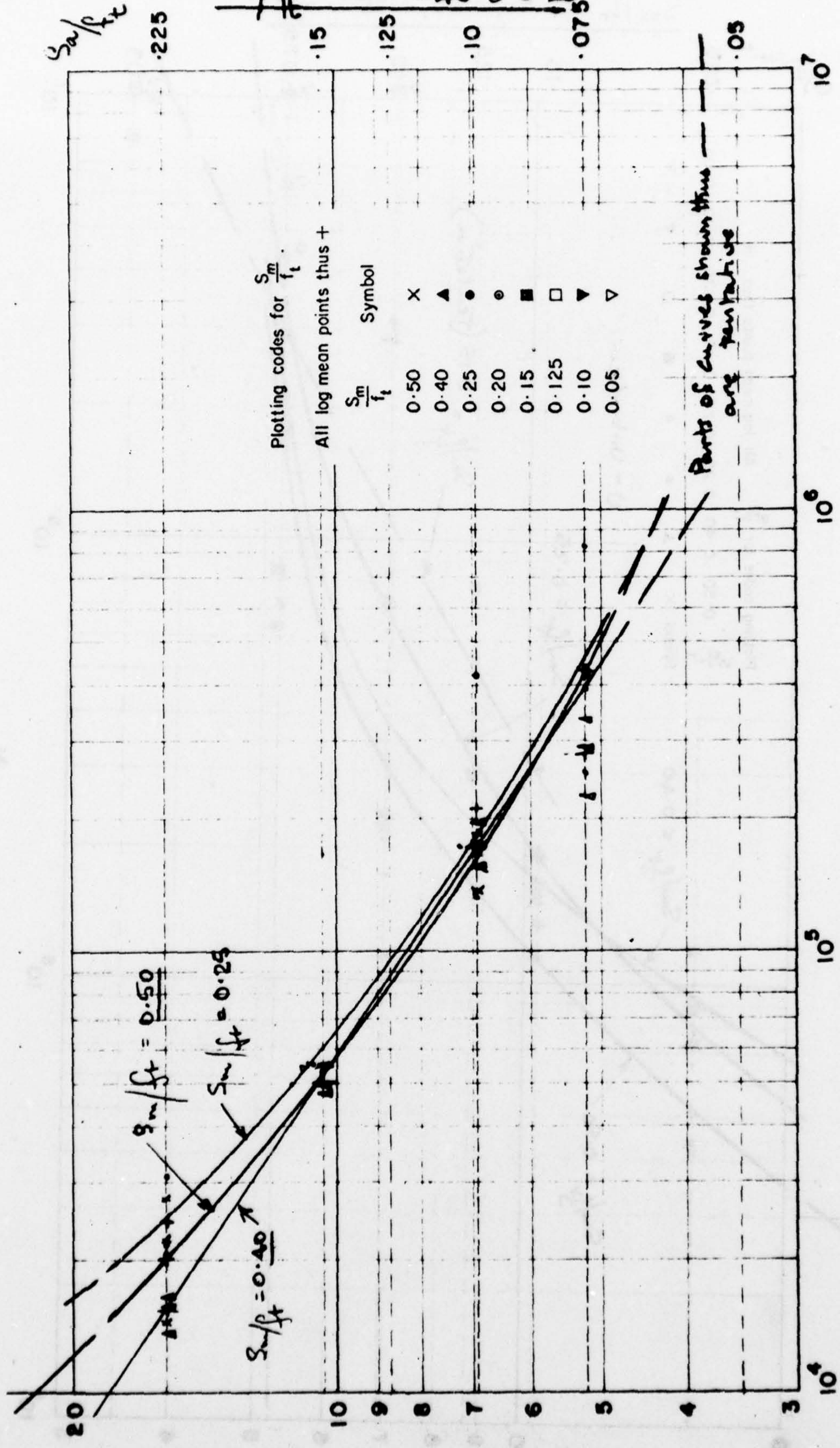


FIG C.21 MEDIUM SPECIMENS TYPE 2.A.5/16 ($d/D = 1/4$)

112

PUSH FIT PIN - PIN UNLOADED

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

Ref: TABLE C.21

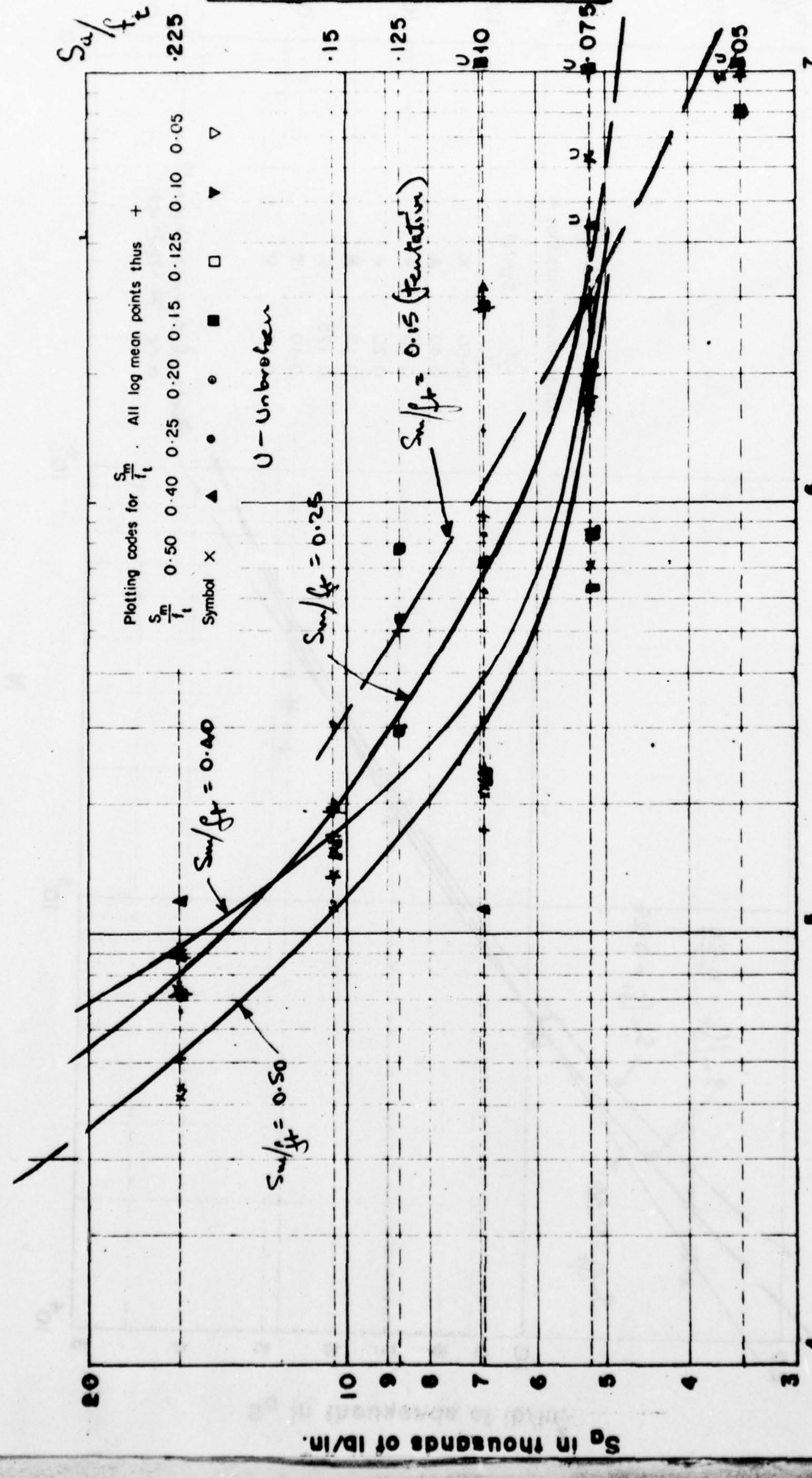


FIG C.22 MEDIUM SPECIMENS TYPE 2A 5/16 (a/D = 1/4) 113

0.4% INTERFERENCE FIT PIN – PIN UNLOADED

S_m/f_t = 0.50, 0.40 & 0.25

Ref: TABLE C.22

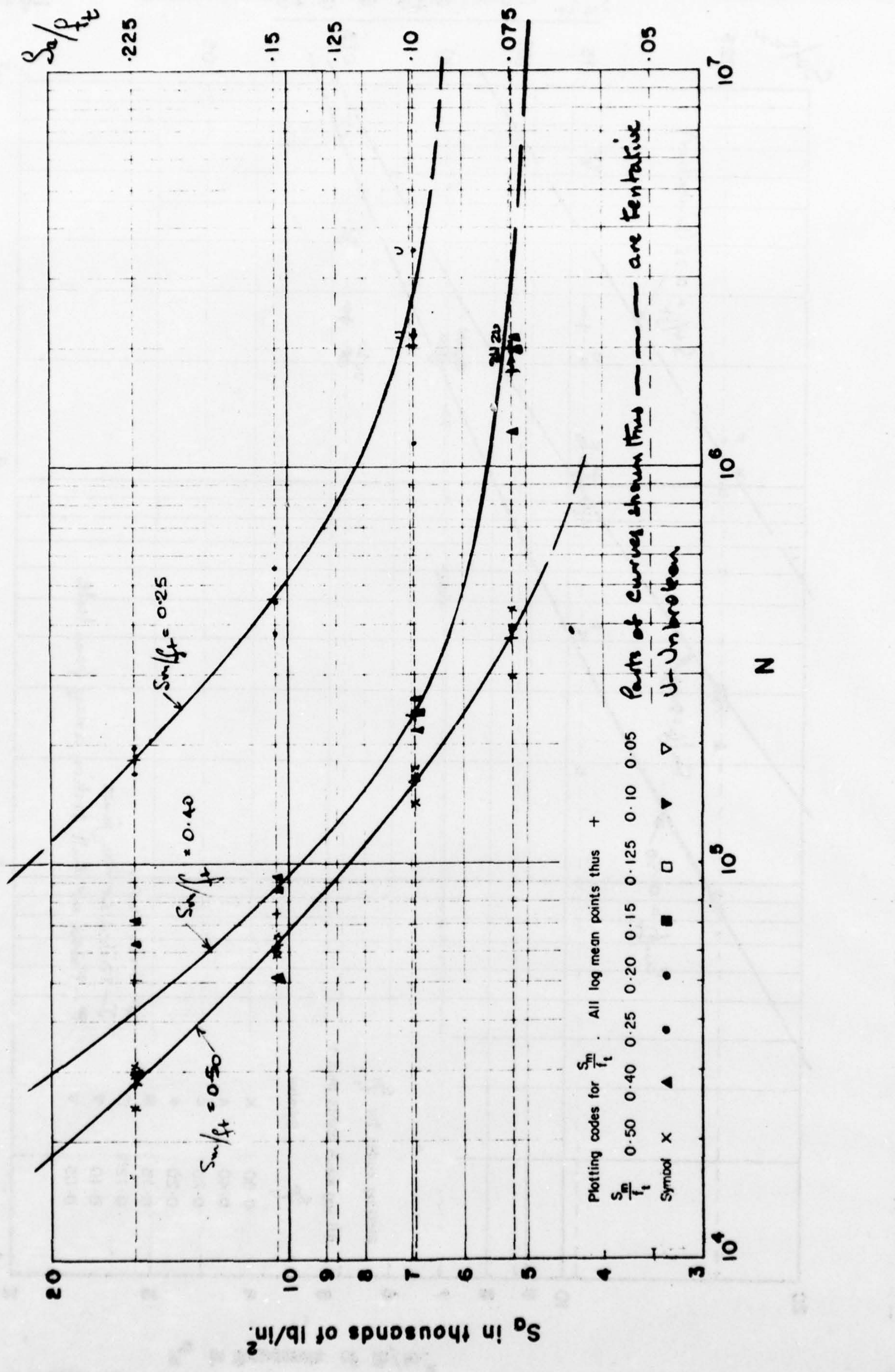


FIG. C.23 MEDIUM SPECIMENS TYPE 2.A.5/6 (a/D = 1/6)

114

0·8% INTERFERENCE FIT PIN – AN UNLOADED

Ref: TABLE C.23

S_m/f_t = 0·50, 0·40 & 0·25

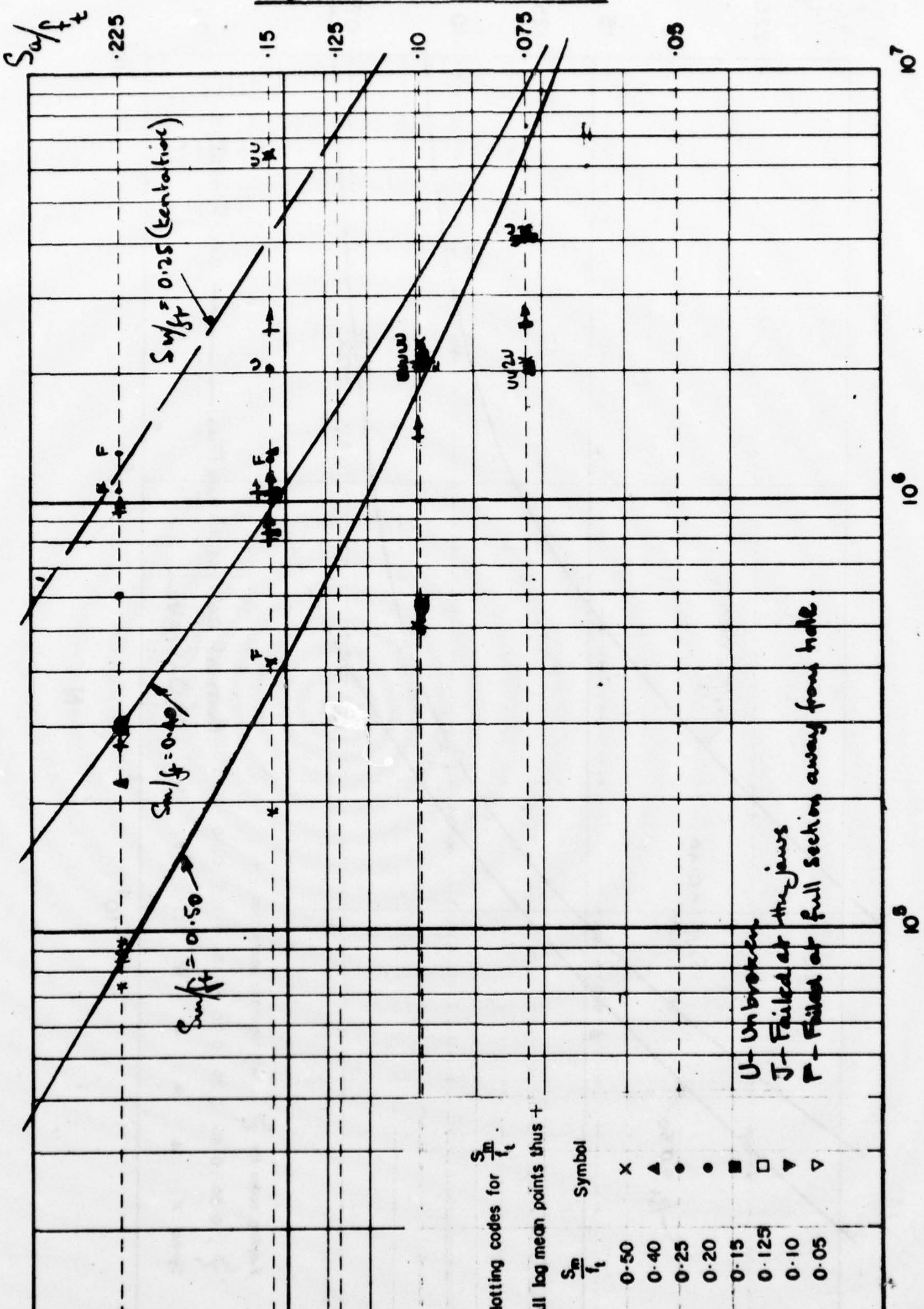


FIG. C.24 MEDIUM SPECIMENS TYPE 2.B.5/16 (d/D = 1/4)

PUSH FIT PIN – PIN LOADED

S_m/f_t = 0.50, 0.40 & 0.25 Ref: TABLE C.24

GROUPS (a) & (b) COMBINED (FROM FIGS. C.24 (a) & (b))

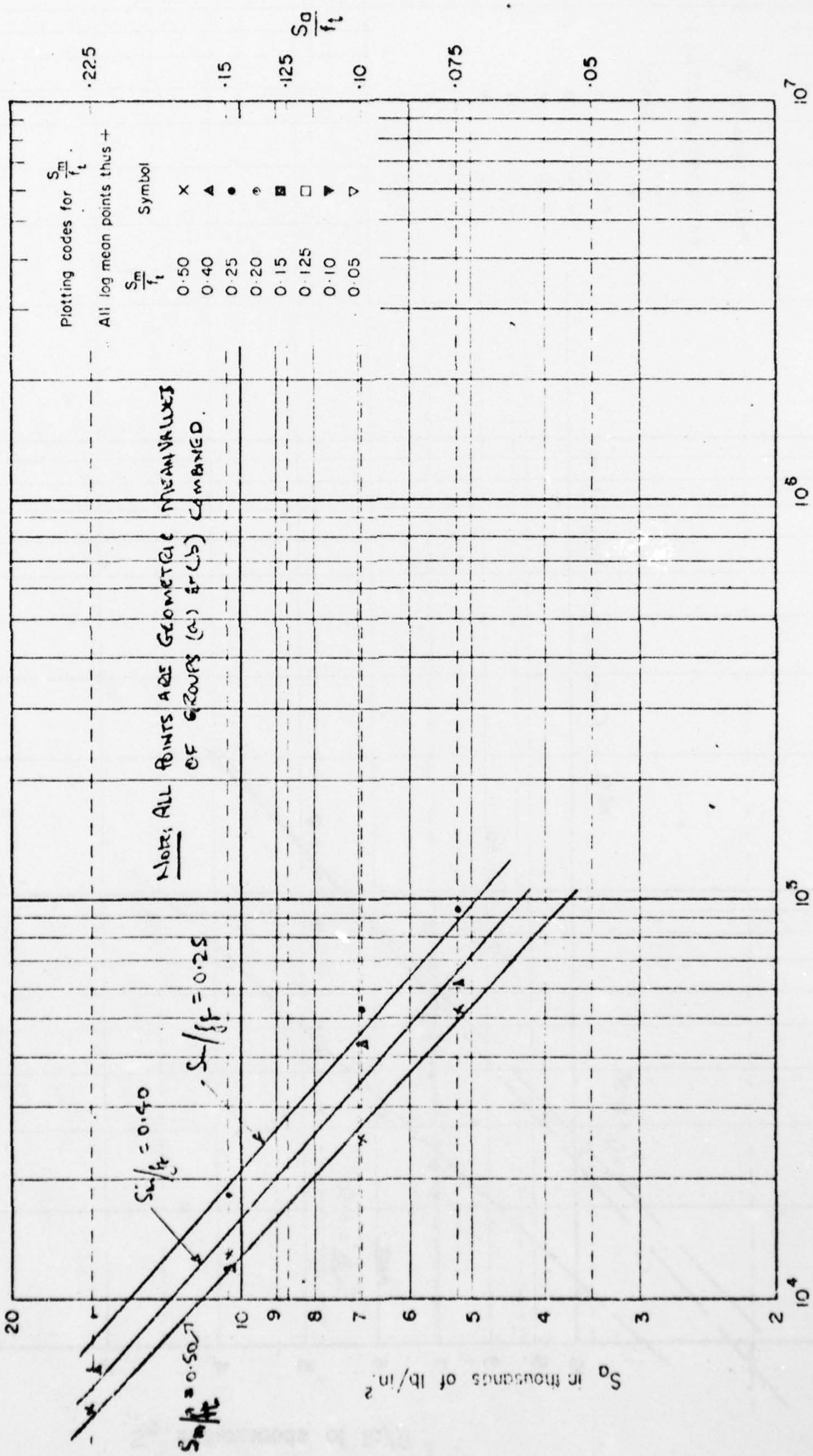


FIG. C.24(a) MEDIUM SPECIMENS TYPE 2.8.5/16 ($d/D = 1/4$)

116

PUSH FIT PIN – PIN LOADED REF: TABLE C.24

$S_m/f_t = 0{\cdot}50,\ 0{\cdot}40\ \&\ 0{\cdot}25$ GROUP (a)

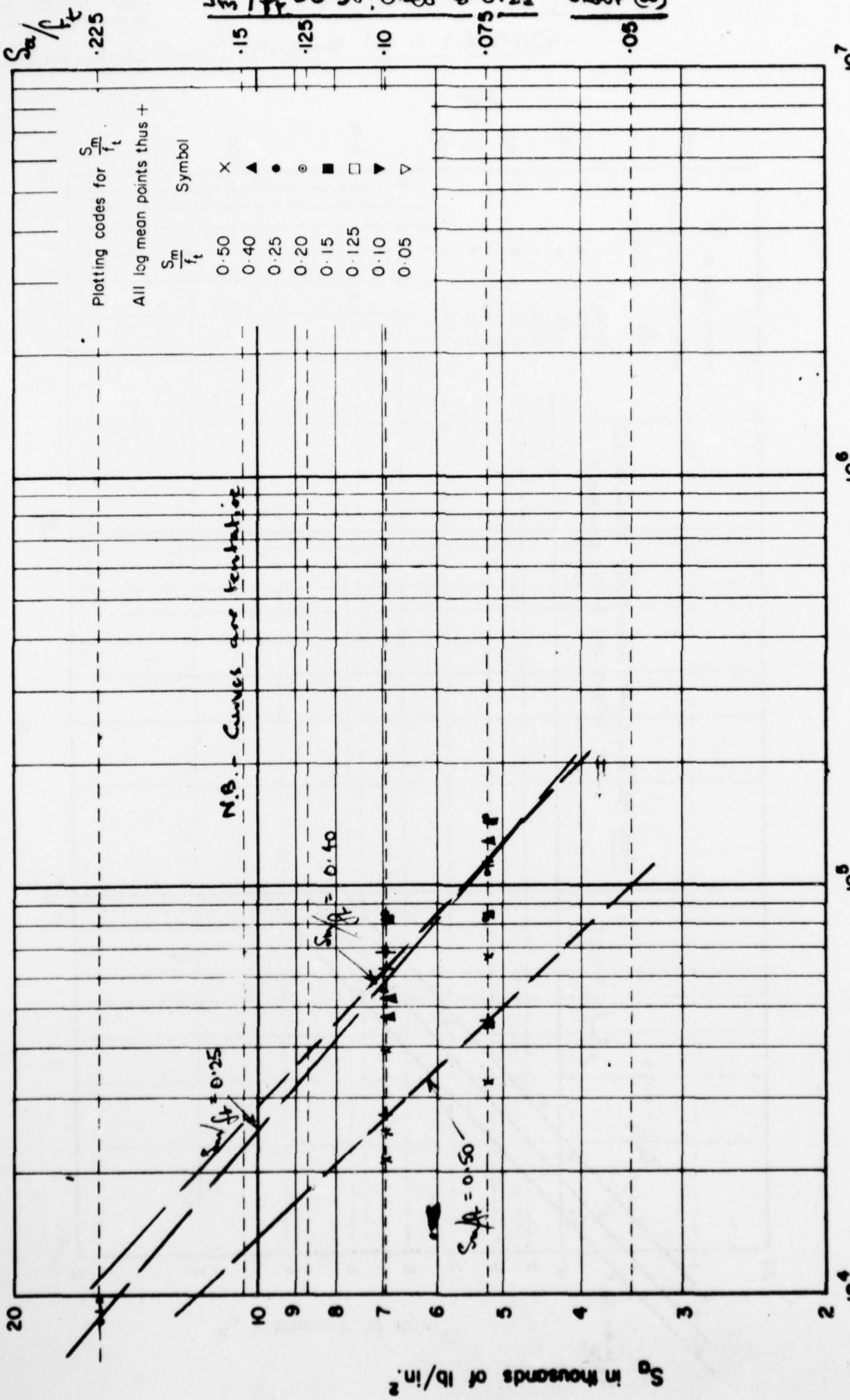


FIG C.21 (b) MEDIUM SPECIMENS TYPE 2.2 5/16 (d/D = 1/4)

PUSH FIT PIN – PIN LOADED

Ref TABLE C.24

S_m/f_t = 0.50, 0.40 & 0.25 GROUP (b)

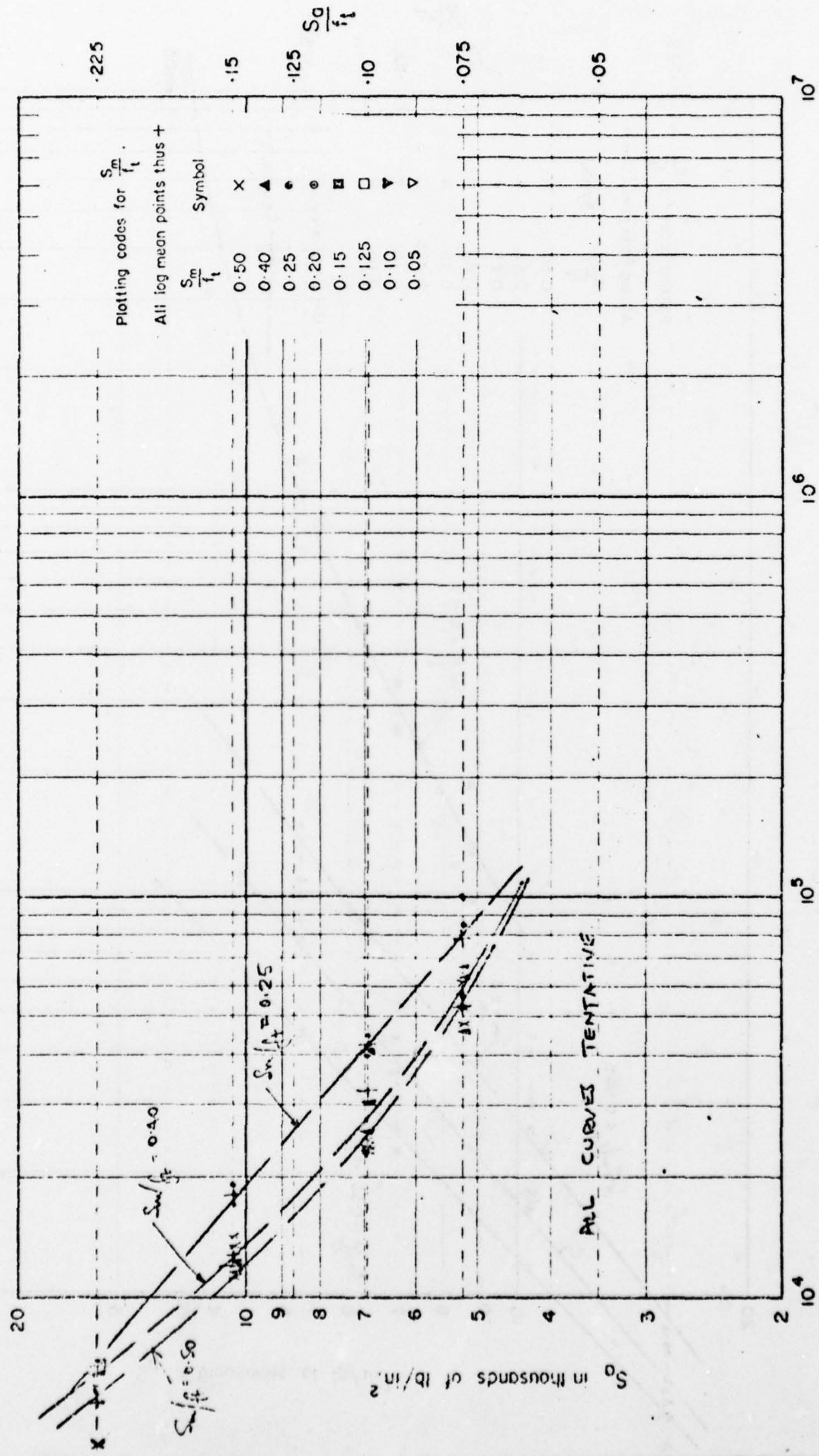


FIG C.25 MEDIUM SPECIMENS TYPE 2 B. 5/16 ($a/D = 1/4$)

0.4% INTERFERENCE FIT PIN — PIN LOADED

Ref. TABLE C.25

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

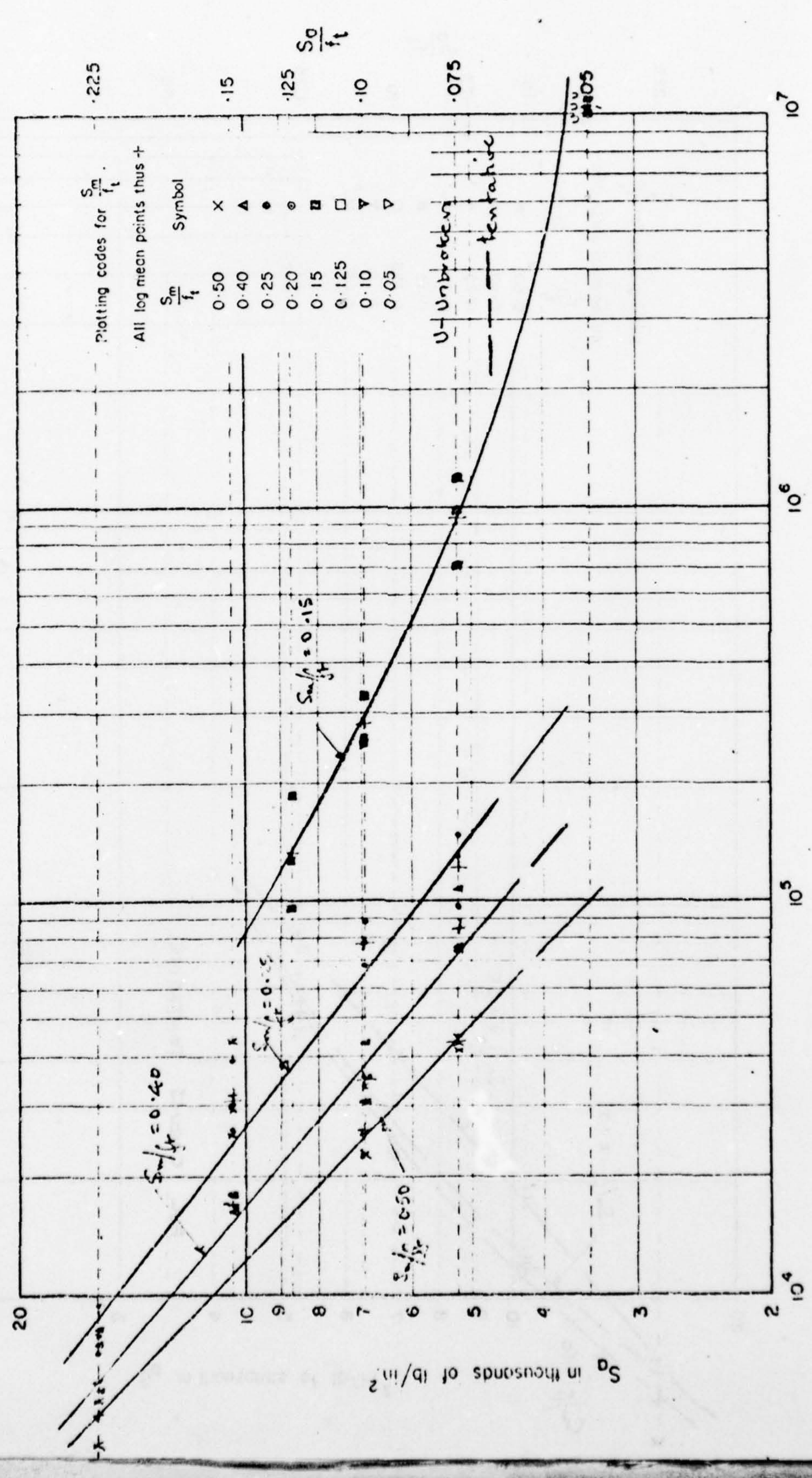


Fig. C.26 MEDIUM SPECIMENS: TYPE 2.B.5/16 ($d/D = 1/4$)

0.8% INTERFERENCE FIT PIN – PIN LOADED

S_m/f_t = 0.50, 0.40 & 0.25 Ref: TABLE C.26

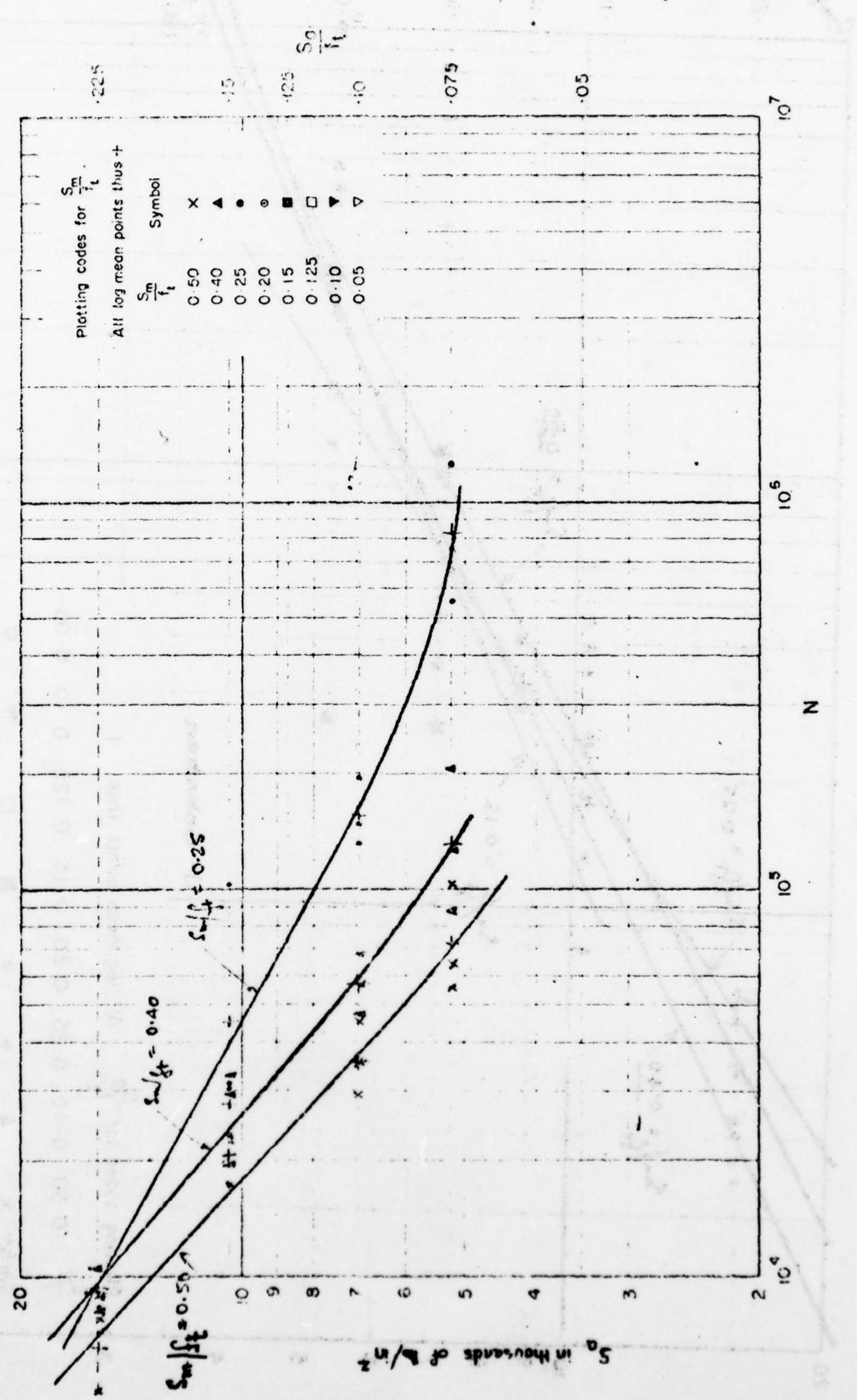


FIG. C.27 MEDIUM SPECIMENS TYPE 2.C.15/32 ($d/D = 3/8$)

120

UNFILLED HOLE

Ref: TABLE C.27

$S_m/f_t = 0{\cdot}50,\ 0{\cdot}40,\ 0{\cdot}25\ \&\ 0{\cdot}15$

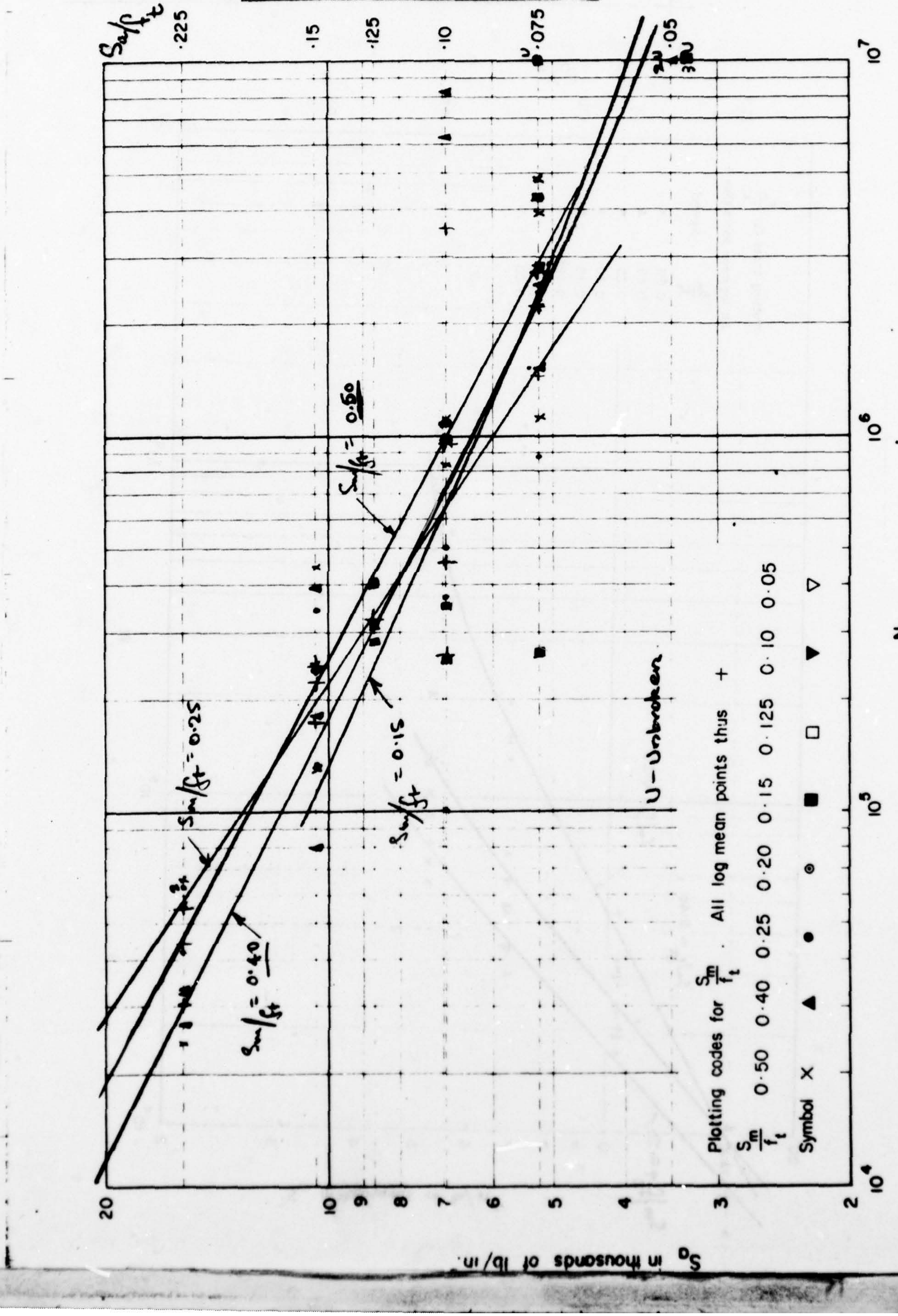


FIG. C.28 MEDIUM SPECIMENS TYPE 2.C.15/32 (d/D = 3/10)

PUSH FIT PIN — PIN UNLOADED

Ref: TABLE C.28

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

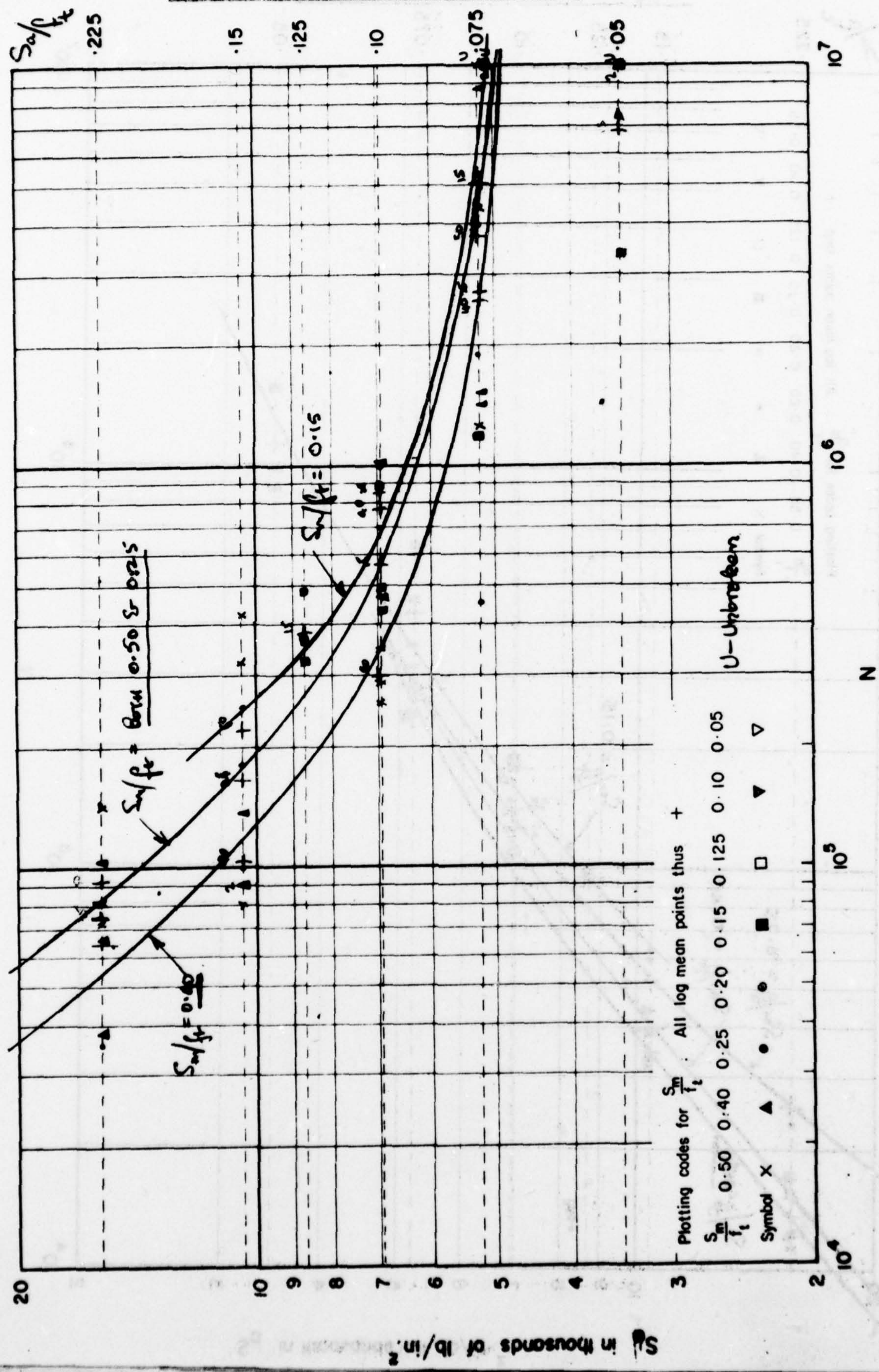


FIG. C .29 MEDIUM SPECIMENS TYPE 2.C.5/8 ($d/D = 1/2$)

122

UNFILLED HOLE

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

Ref: TABLE C.29

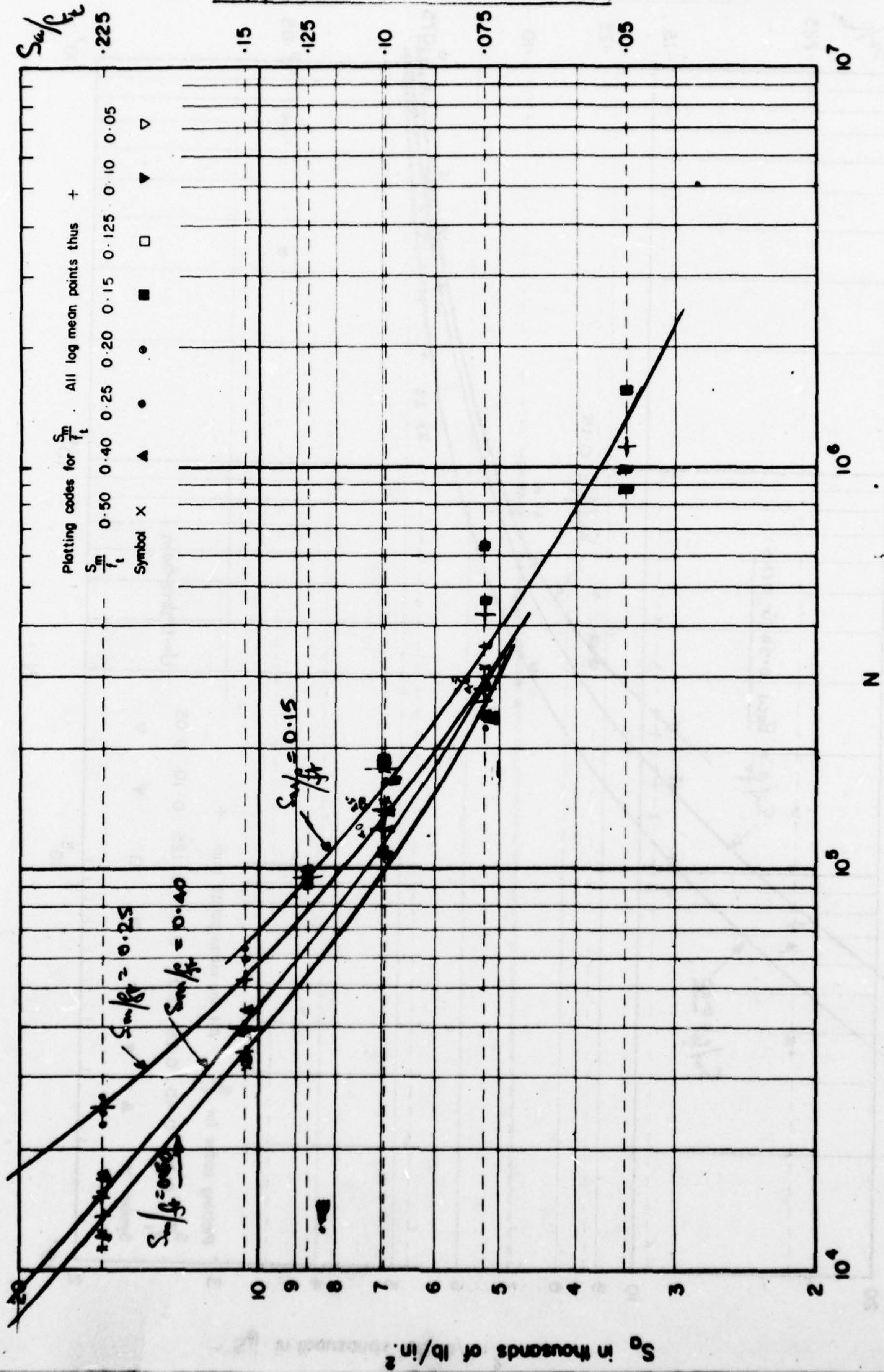


FIG. C.30 MEDIUM SPECIMENS TYPE 2.C.5/8 (a/D = 1/2)

PUSH FIT PIN - PIN UNLOADED

S_m/f_t = 0·50 & 0·40

REF. TABLE C.1-30

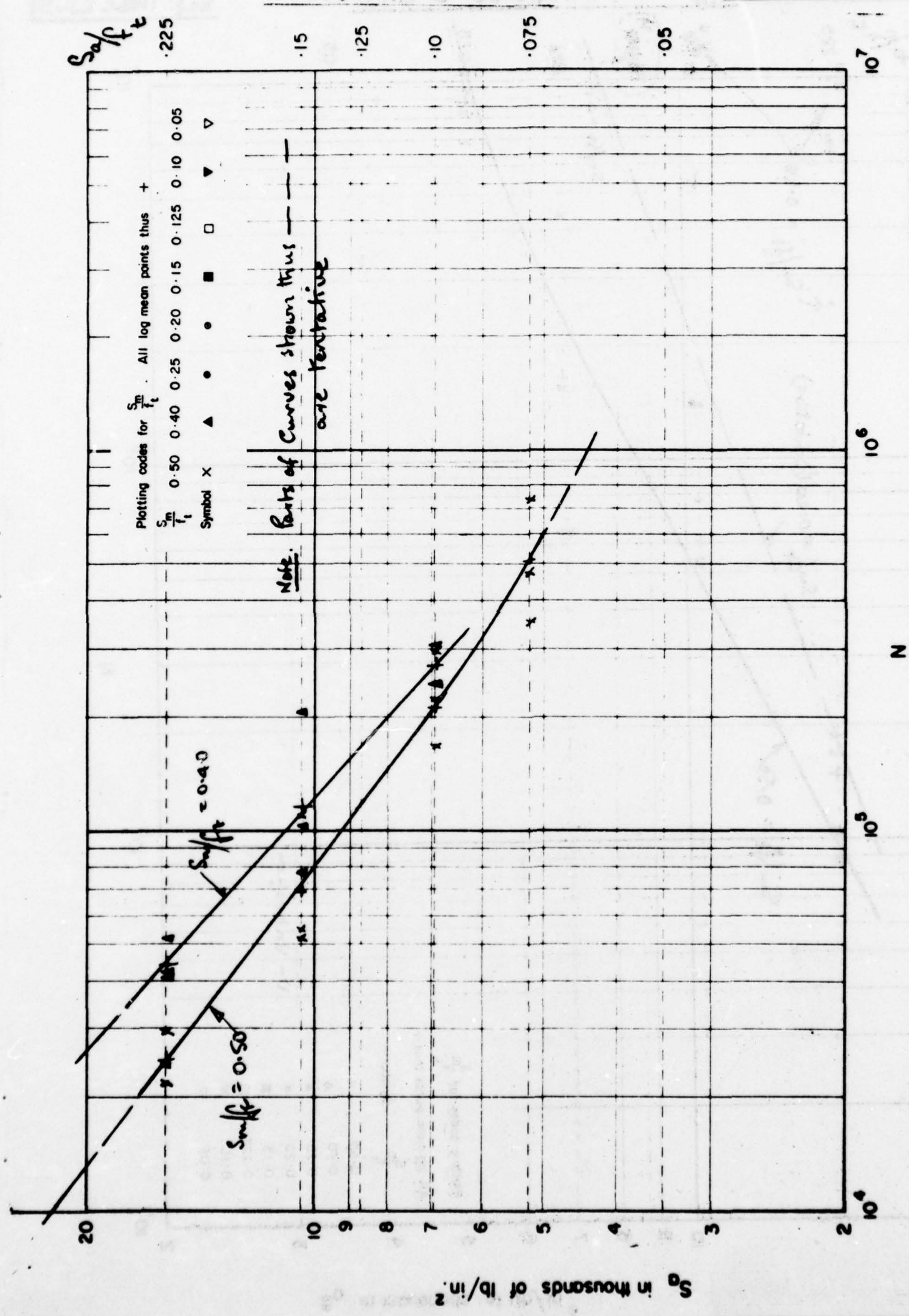


FIG. C.31 MEDIUM SPECIMENS TYPE 2.C.5/8 ($a/b = \frac{1}{2}$)

0.4% INTERFERENCE FIT PIN - PIN UNLOADED

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

Ref: TABLE C.31

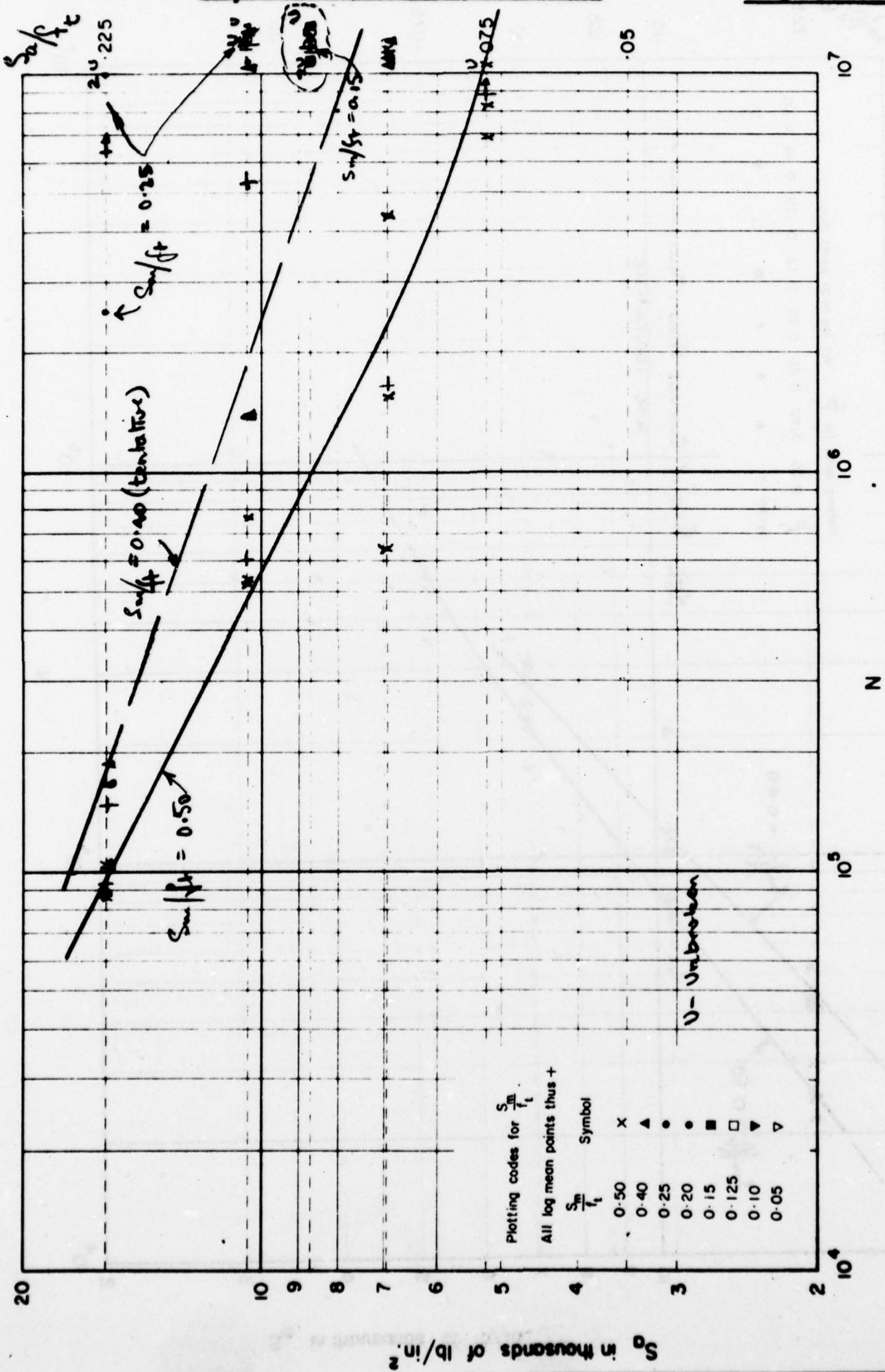


FIG. C.32 MEDIUM SPECIMENS TYPE 2D.5/8 ($d/D = 1/2$)

PUSH FIT PIN – PIN LOADED

Ref: TABLE C.32

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

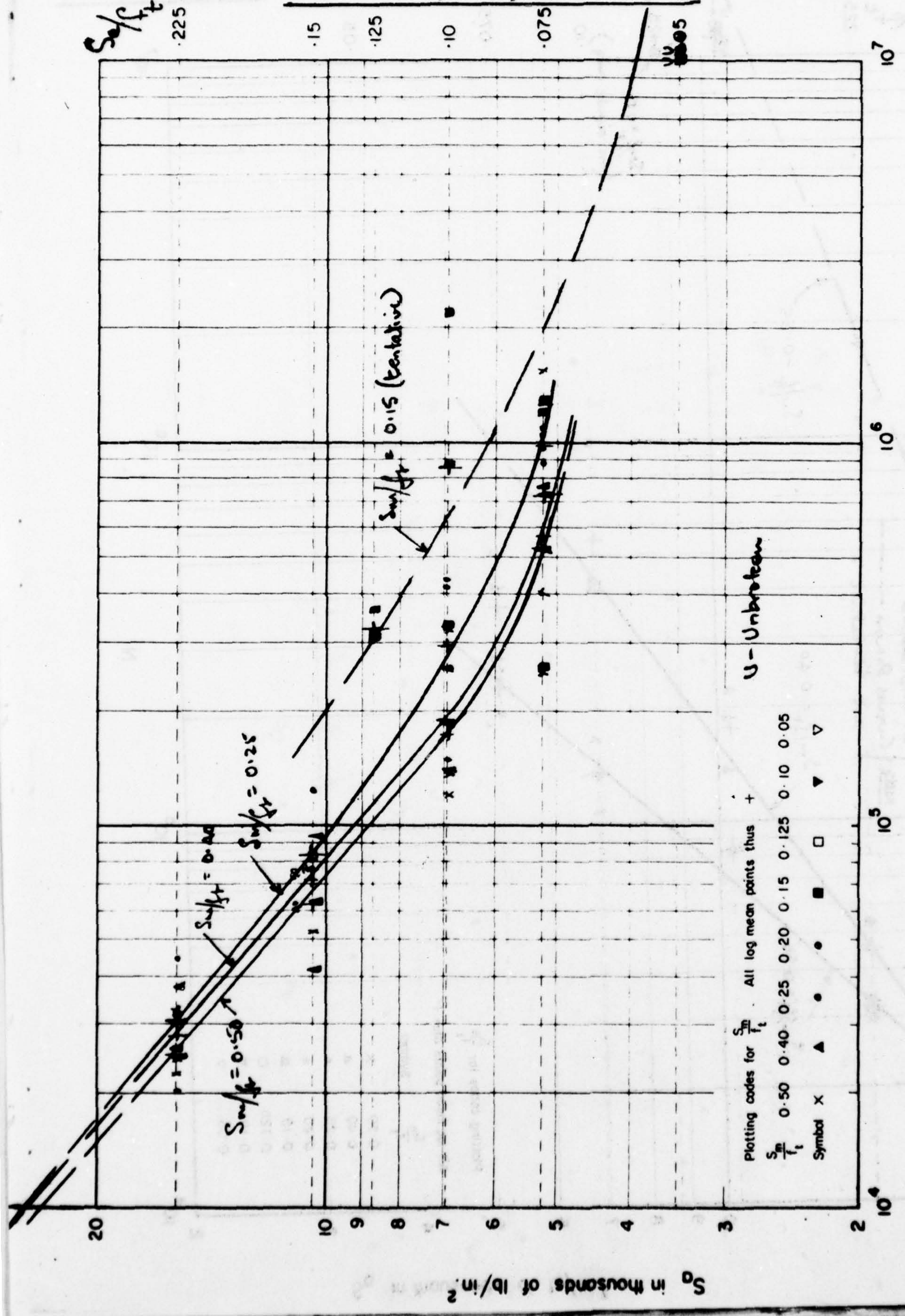


FIG. C.33 MEDIUM SPECIMENS TYPE 2.D.5/8 (d/D=1/2)

126

0.4% INTERFERENCE FIT PIN - PIN LOADED

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

Ref. TABLE C.33

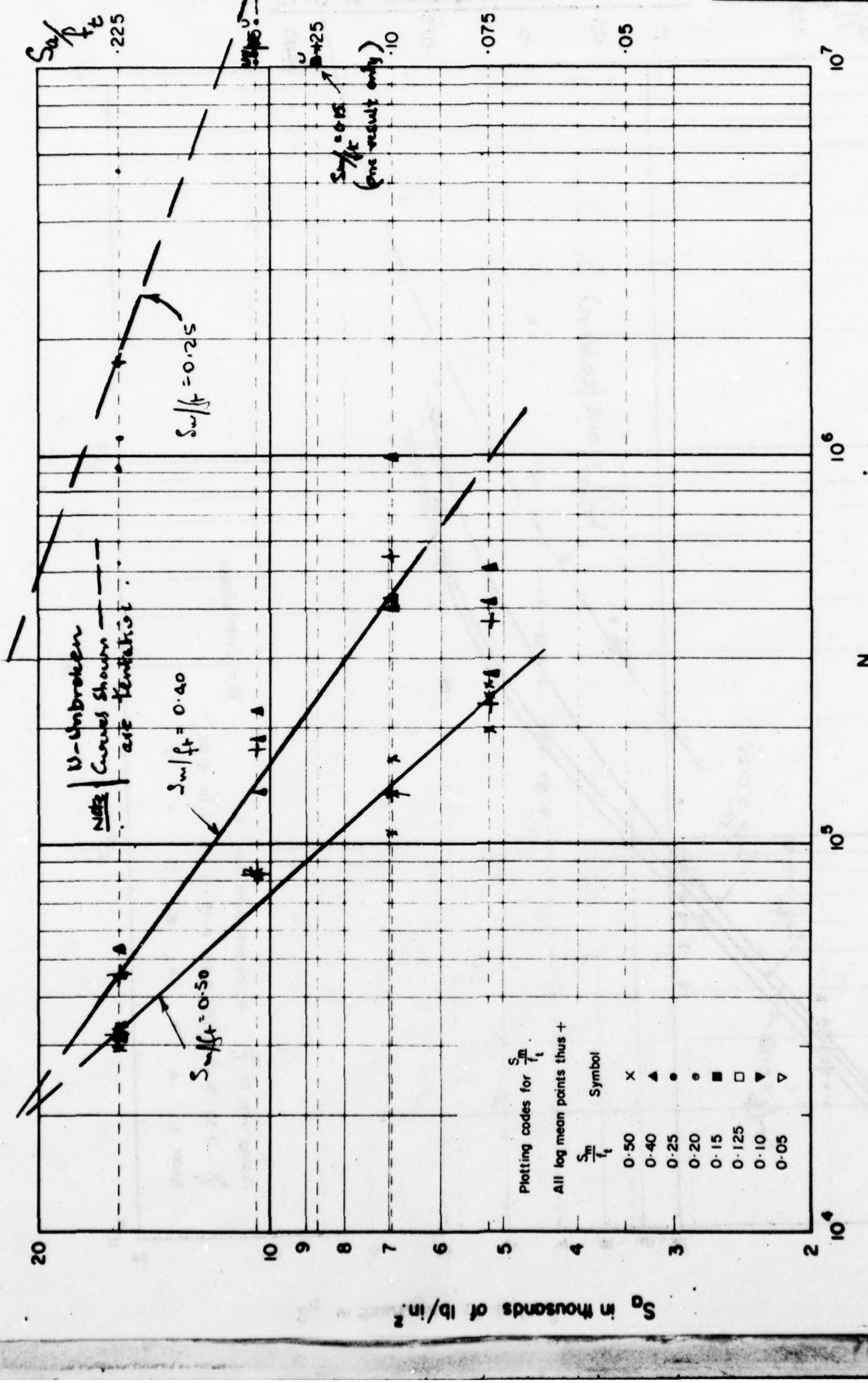


FIG. C.34 MEDIUM SPECIMENS TYPE 2.D.5/8 ($d/D = 1/2$)

0.8% INTERFERENCE FIT PIN – PIN LOADED

S_m/f_t = 0.50, 0.40 & 0.25

Ref: TABLE C.34

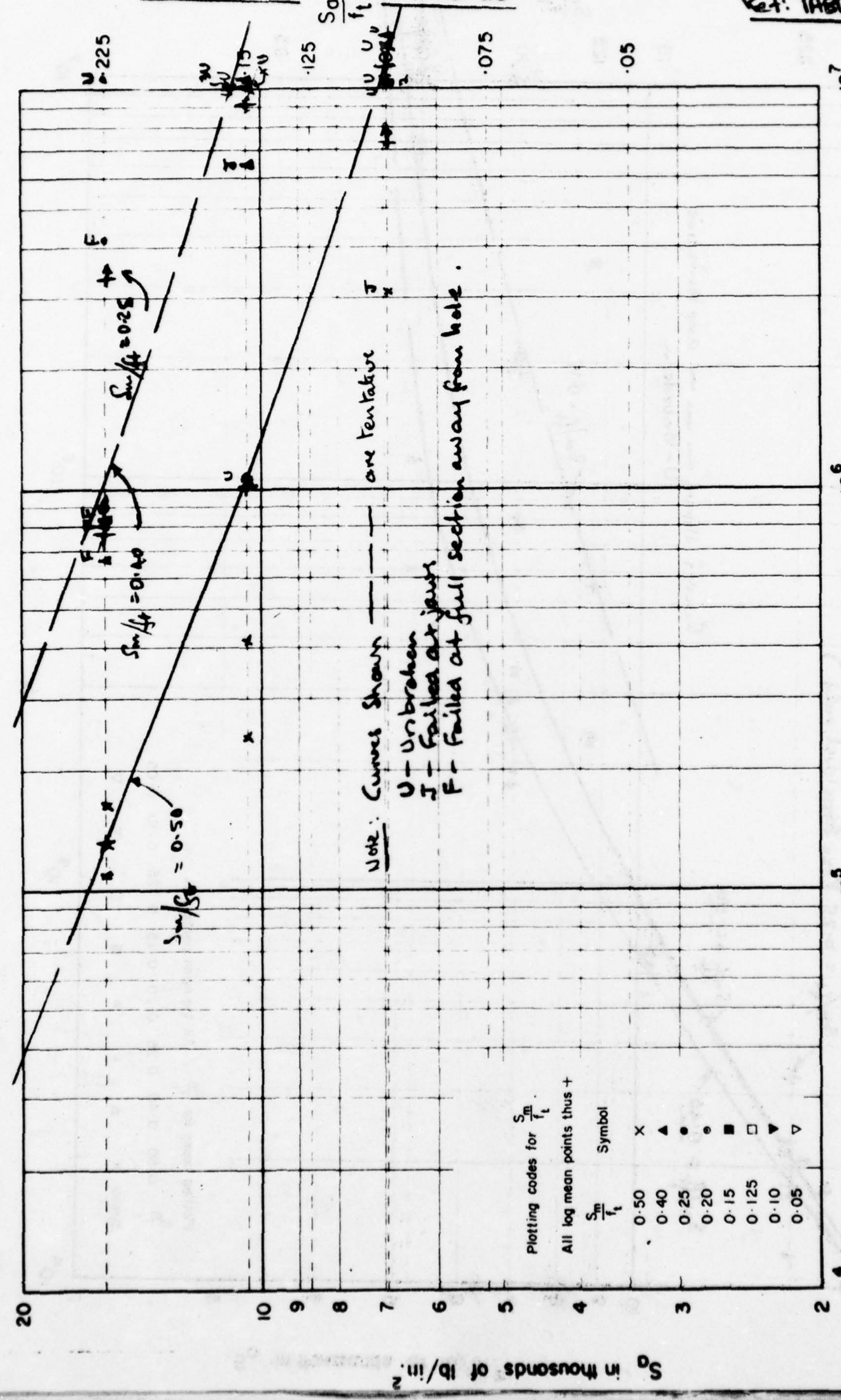


FIG. C.35 SMALL SPECIMENS TYPE 4A 3/16 ($d/D = 1/4$)

128

UNFILLED HOLE

Ref. TABLE C.35

$S_m/f_t = 0.50, 0.40, 0.25$ & 0.15

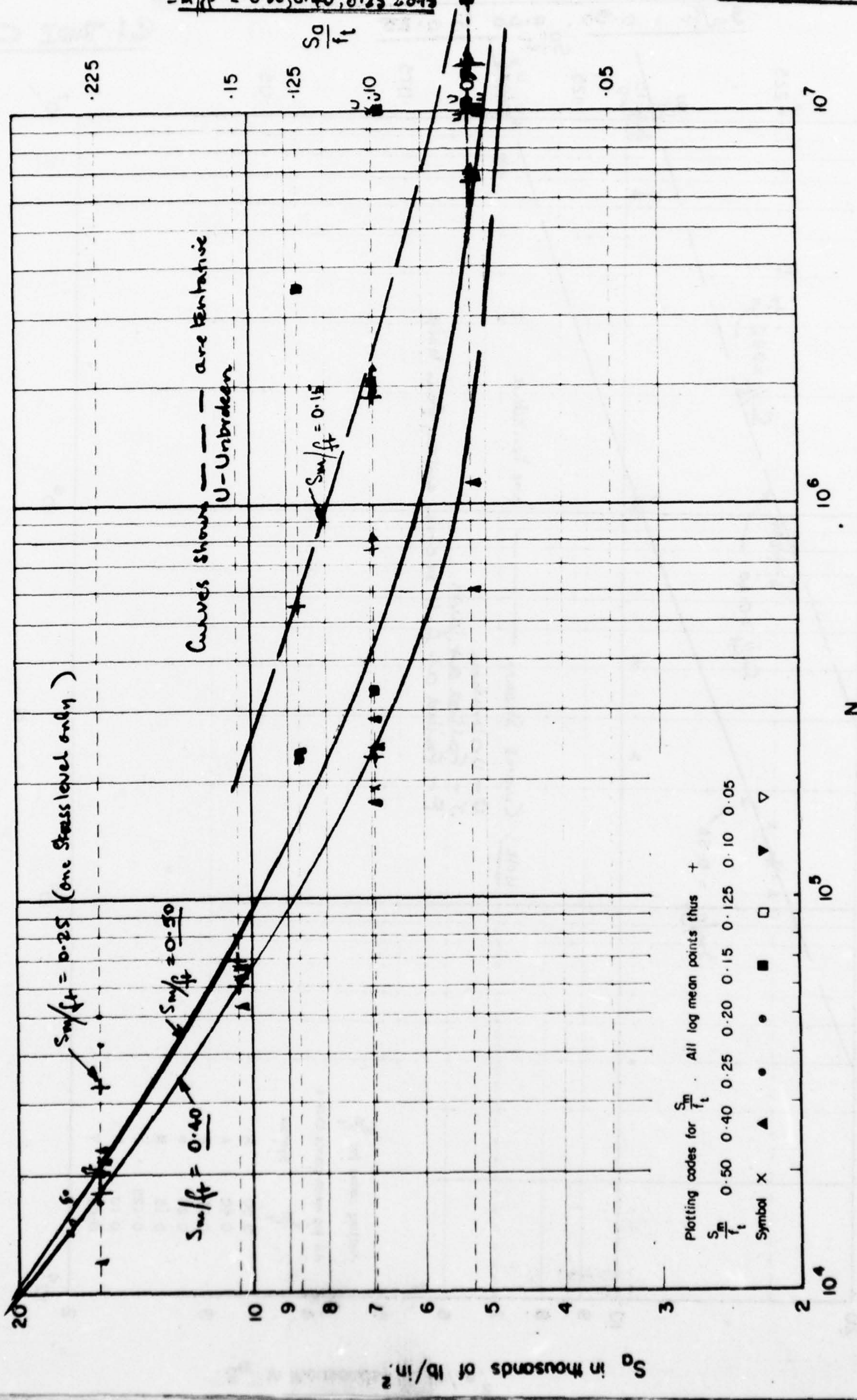


FIG. C.36. SMALL SPECIMENS TYPE 4.A1. 3/16 ($d/D = 1/4$)

LOOSE FIT PIN – PIN UNLOADED

$S_m / f_t = 0.50, 0.40$ & 0.25

Ref: TABLE C.36

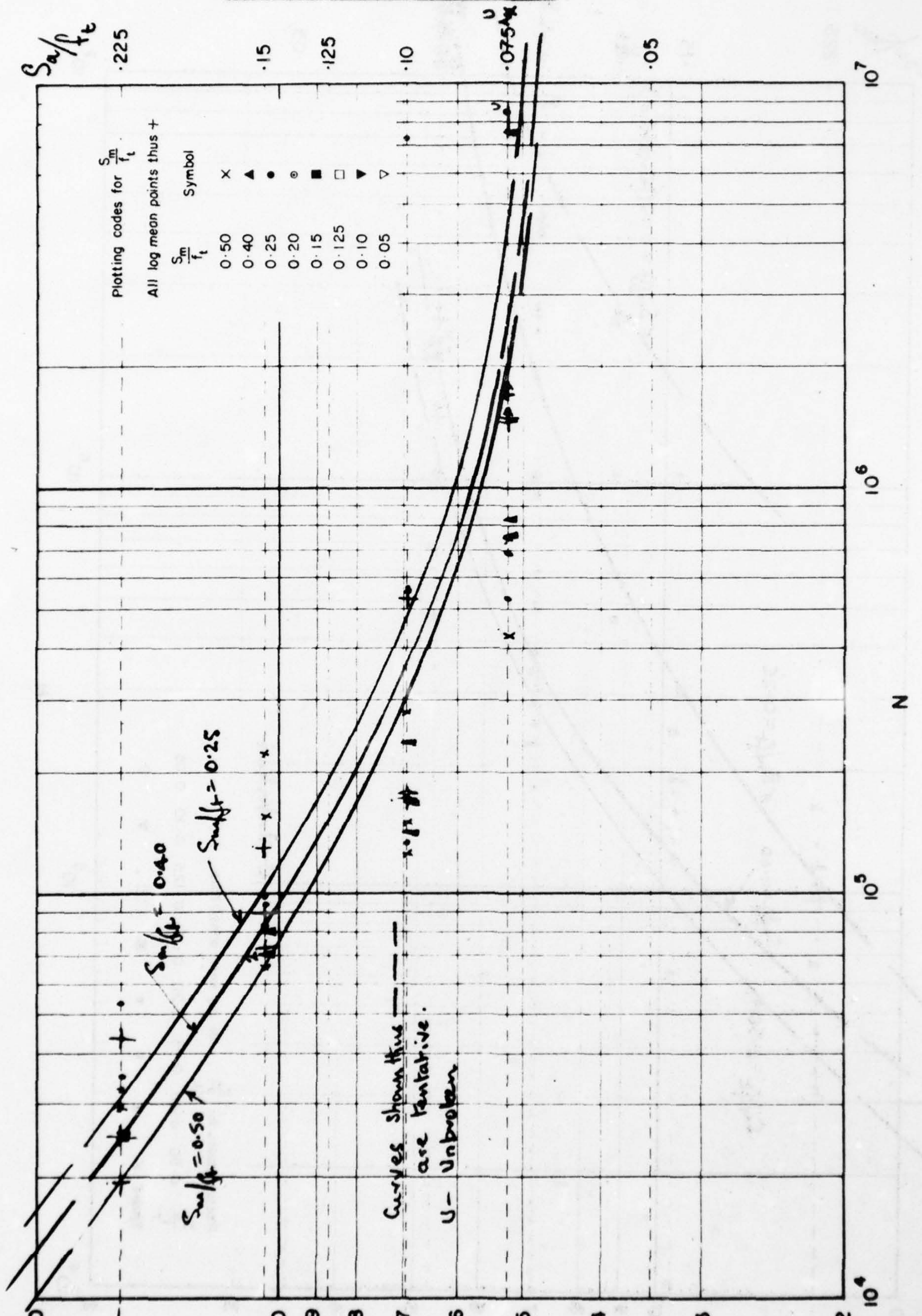


FIG C.37 SMALL SPECIMENS TYPE A.A.3/16 (a/D = 1/4)

130

PUSH FIT PIN - PIN UNLOADED

Ref: TABLE C.37

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

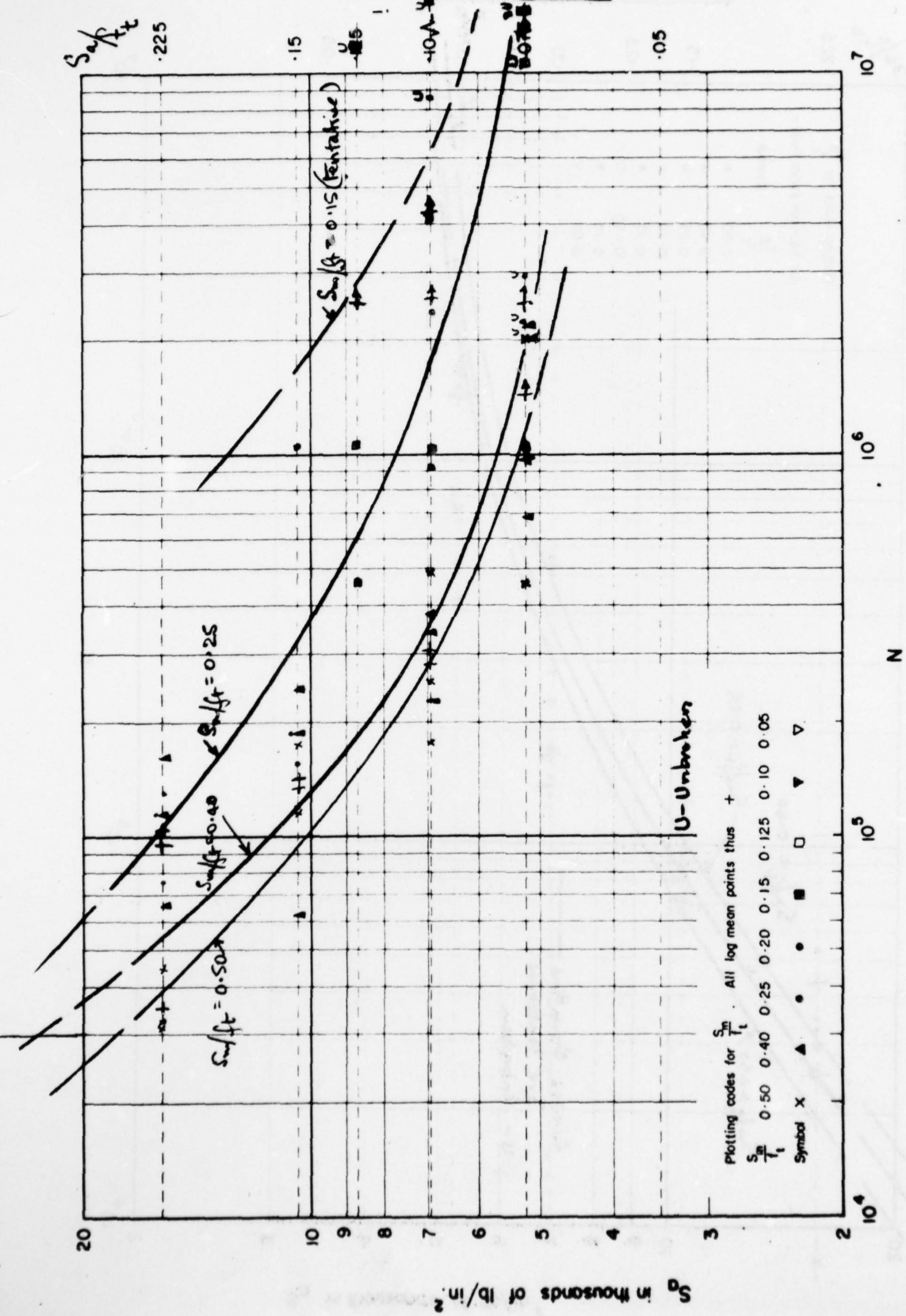


FIG. C.38 SMALL SPECIMENS TYPE 4.A1.3A0 (d/D = 1/4)

0·4% INTERFERENCE FIT AN - PIN UNLOADED

S_m/f_t = 0·50, 0·40 & 0·25

Ref: TABLE C.38.

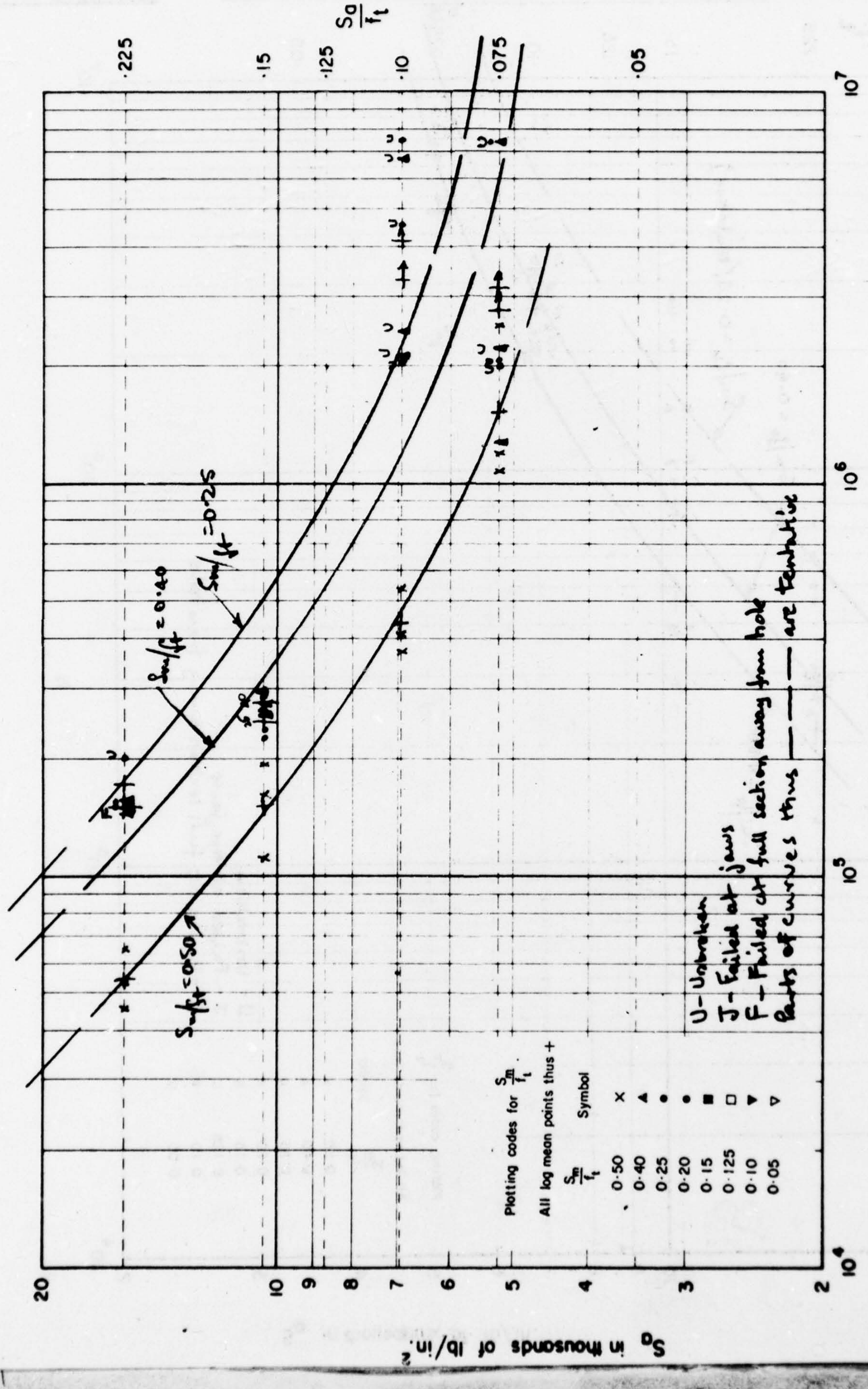


FIG C.39 SMALL SPECIMENS TYPE 4.A1.3/16 (d/D = 1/4)

132 0·8% INTERFERENCE FIT PIN — PIN UNLOADED

Sm/ft = 0·50, 0·40 & 0·25

Ref. TABLE C.39

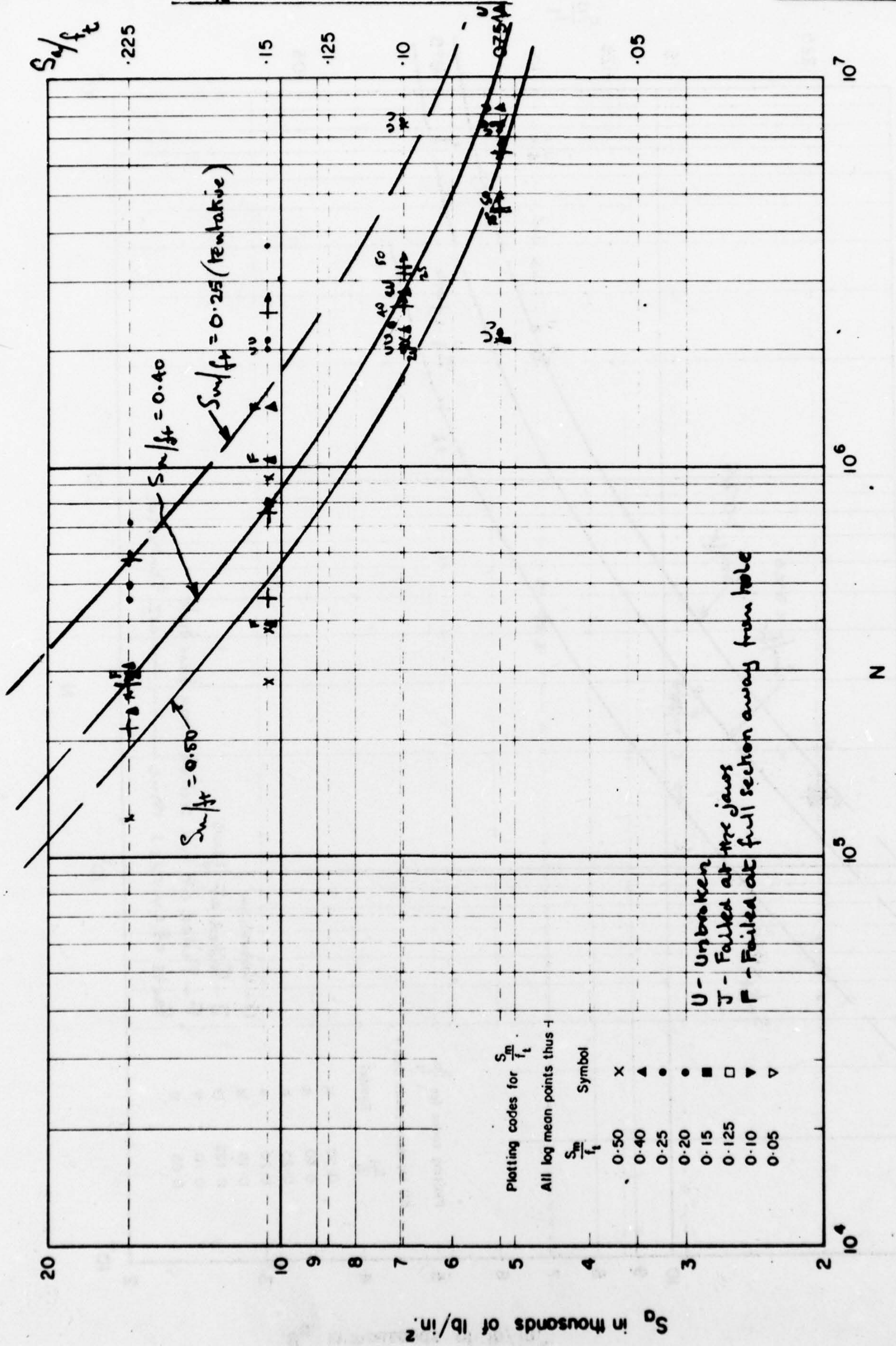


FIG. C40 SMALL SPECIMENS TYPE 4.B.3/16 (d/D = 1/2)

PUSH FIT PIN – PIN LOADED

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

Ref: TABLE C.40

GROUPS (a) & (b) COMBINED

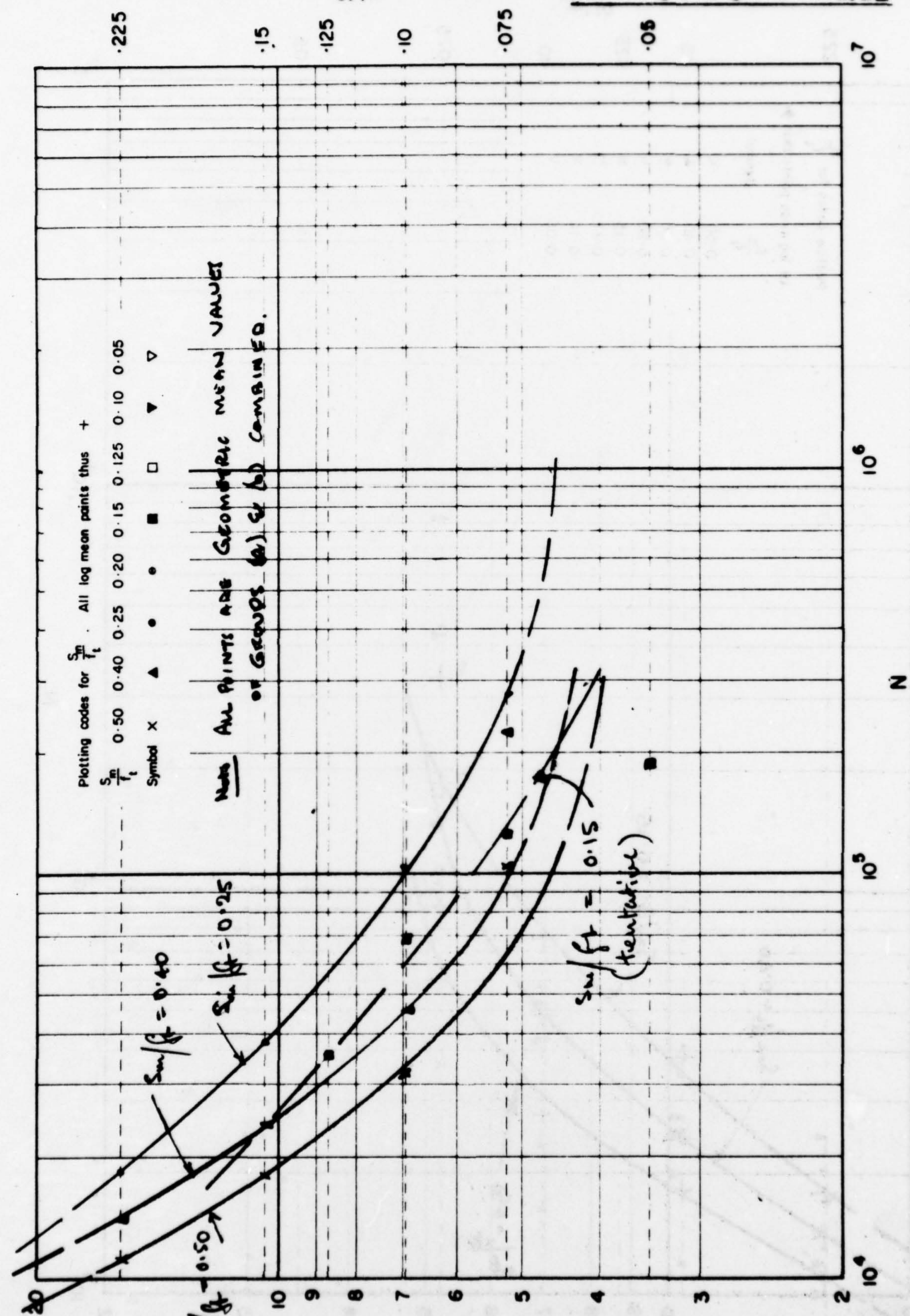


FIG. C.40(a) SMALL SPECIMENS TYPE 4.8.316 (d/D = 1/4)

134

PUSH FIT PIN – PIN LOADED

Ref. TABLE C.40

GROUP (a) $S_m/f_t = 0.50, 0.40 \& 0.25$

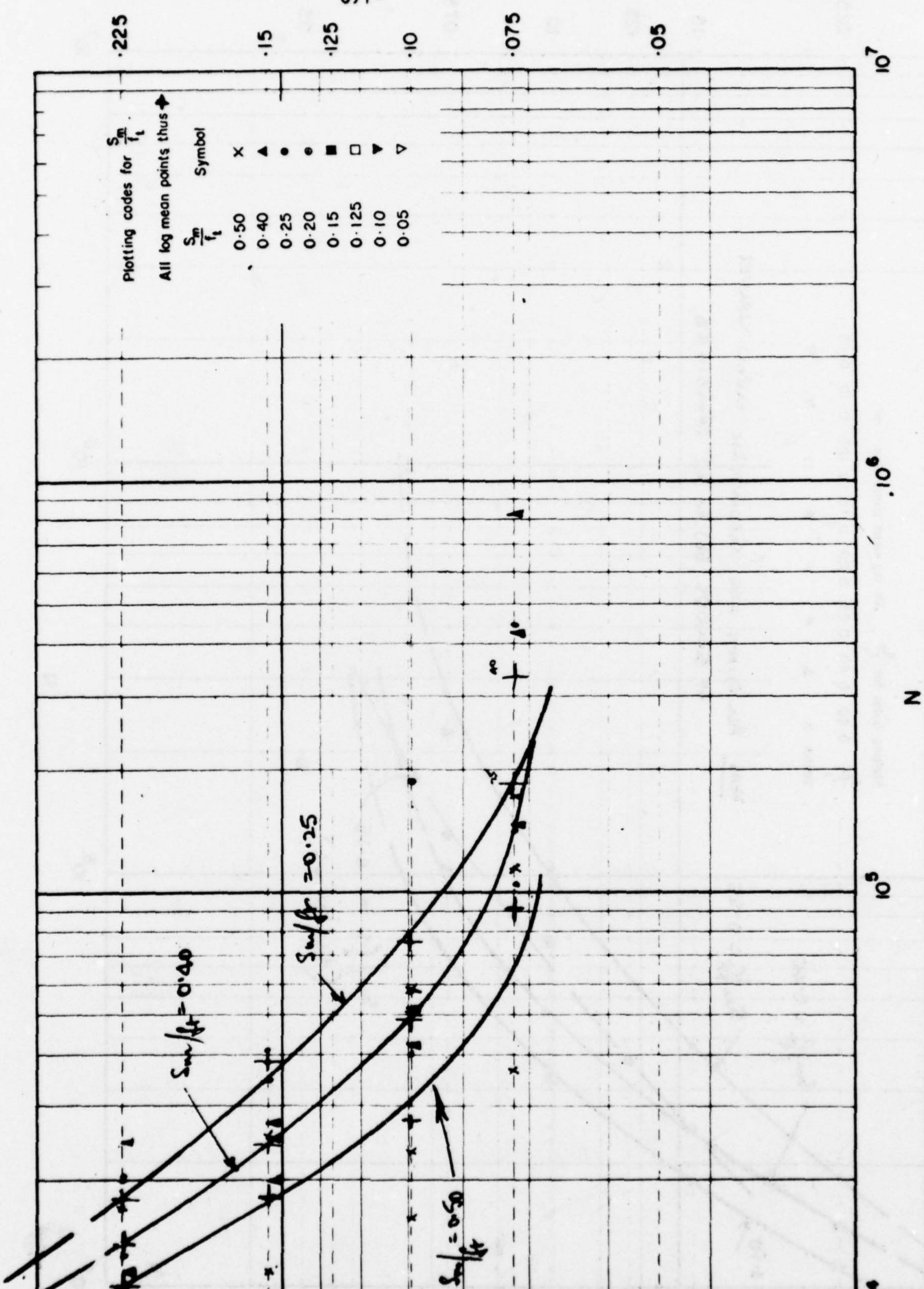


FIG. C.40(b) SMALL SPECIMENS TYPE A.B2.3/16 (9/16"½)

PUSH FIT PIN – PIN LOADED

GROUP (b) S_m/f_t = 0.50, 0.40 0.25 & 0.15

Ref. TABLE

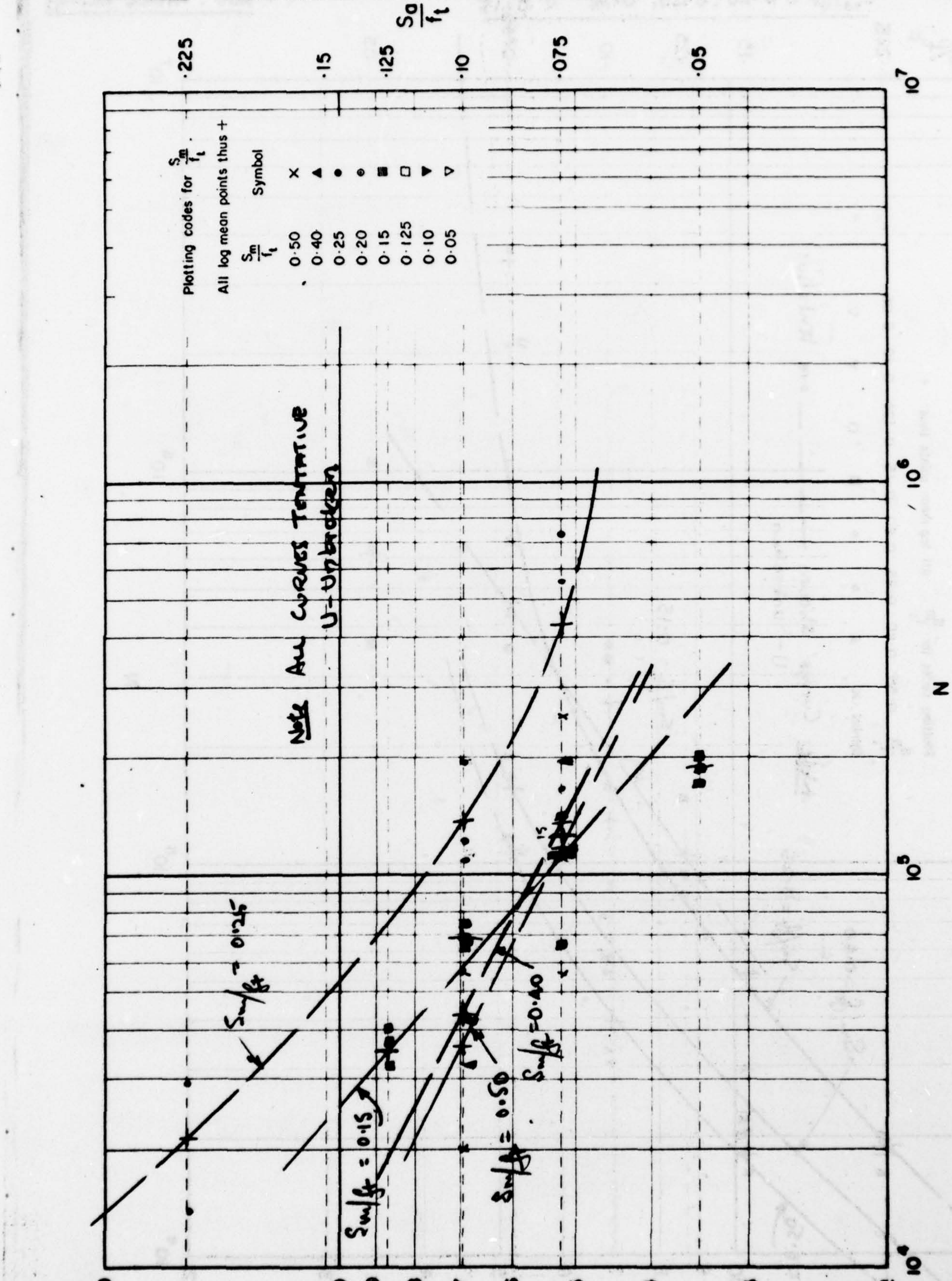


FIG C.41 SMALL SPECIMENS TYPE 4.B1.3/16 (d/D = 1/4)

136 0.4% INTERFERENCE FIT PIN – PIN LOADED

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

Ref: TABLE 13.4

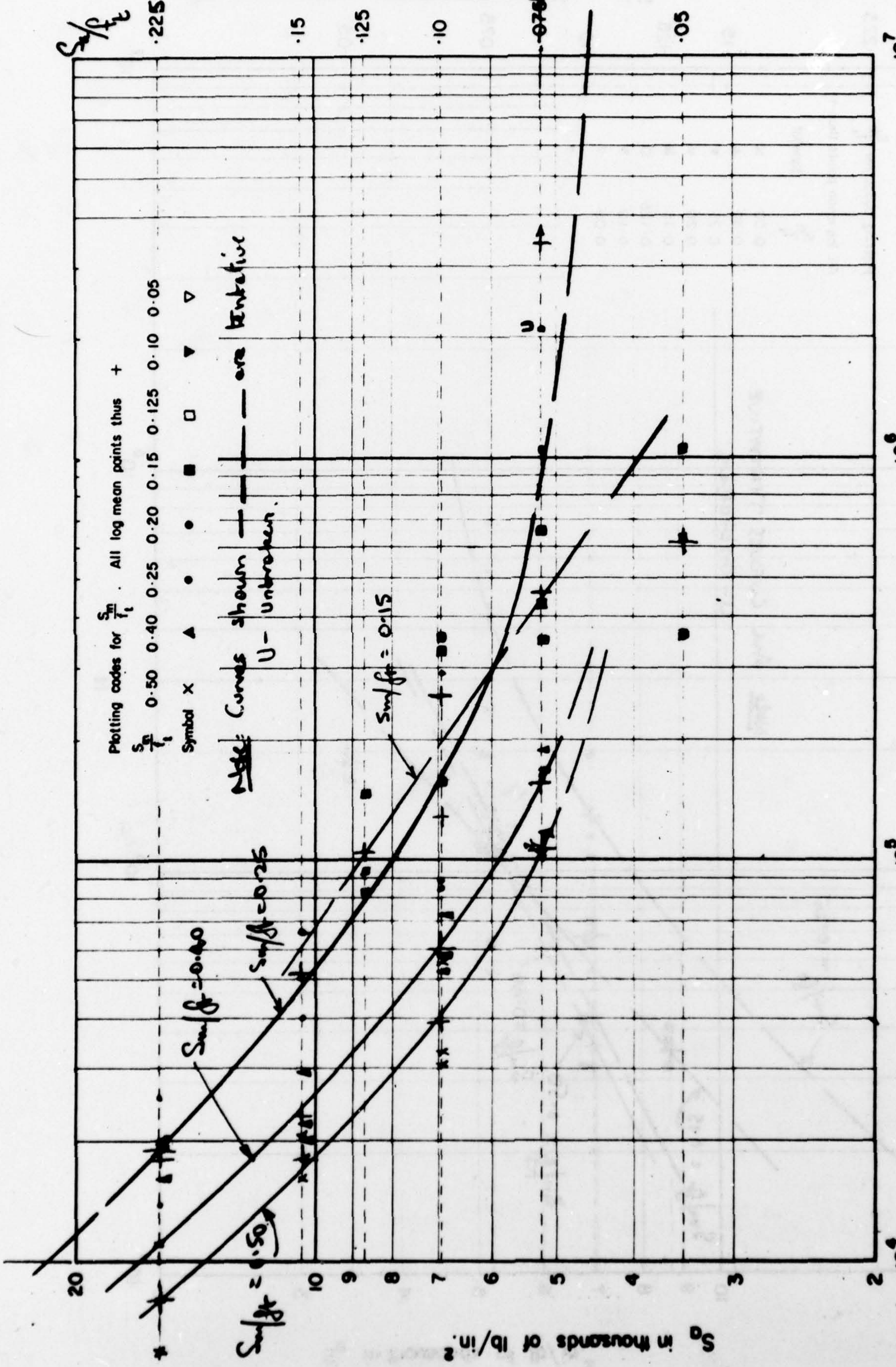


FIG K. 42 SMALL SPECIMENS TYPE 4.B.3/6 (d/D = 1/4)

0.8% INTERFERENCE FIT PIN — PIN LOADED

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

Ref: TABLE K.42

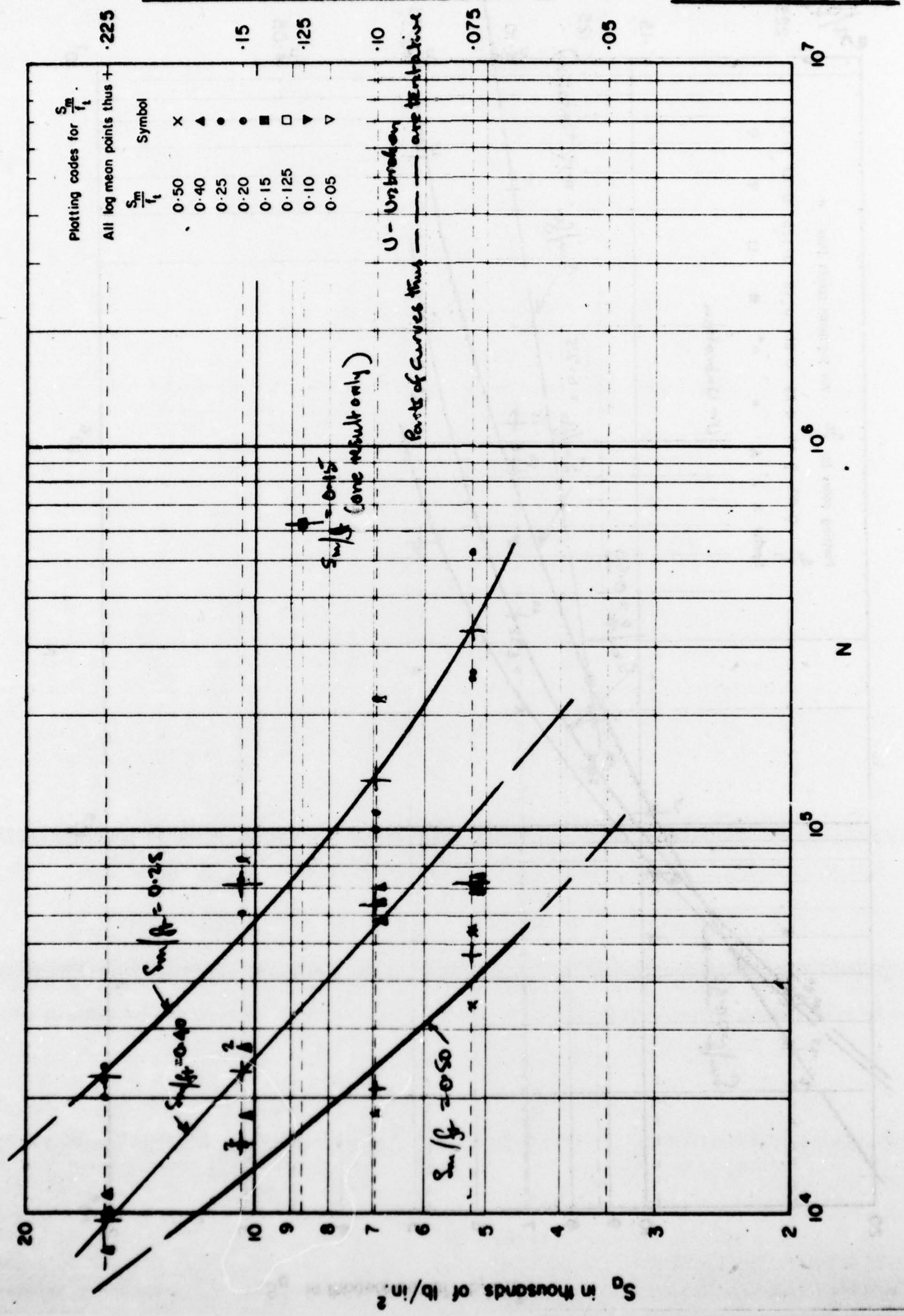


FIG C.43 SMALL SPECIMENS - TYPE 4C9/32 (d/D = 3/8)

138 UNFILLED HOLE Ref. TABLE C.43

S_m/f_t = 0.50, 0.40, 0.25, & 0.15

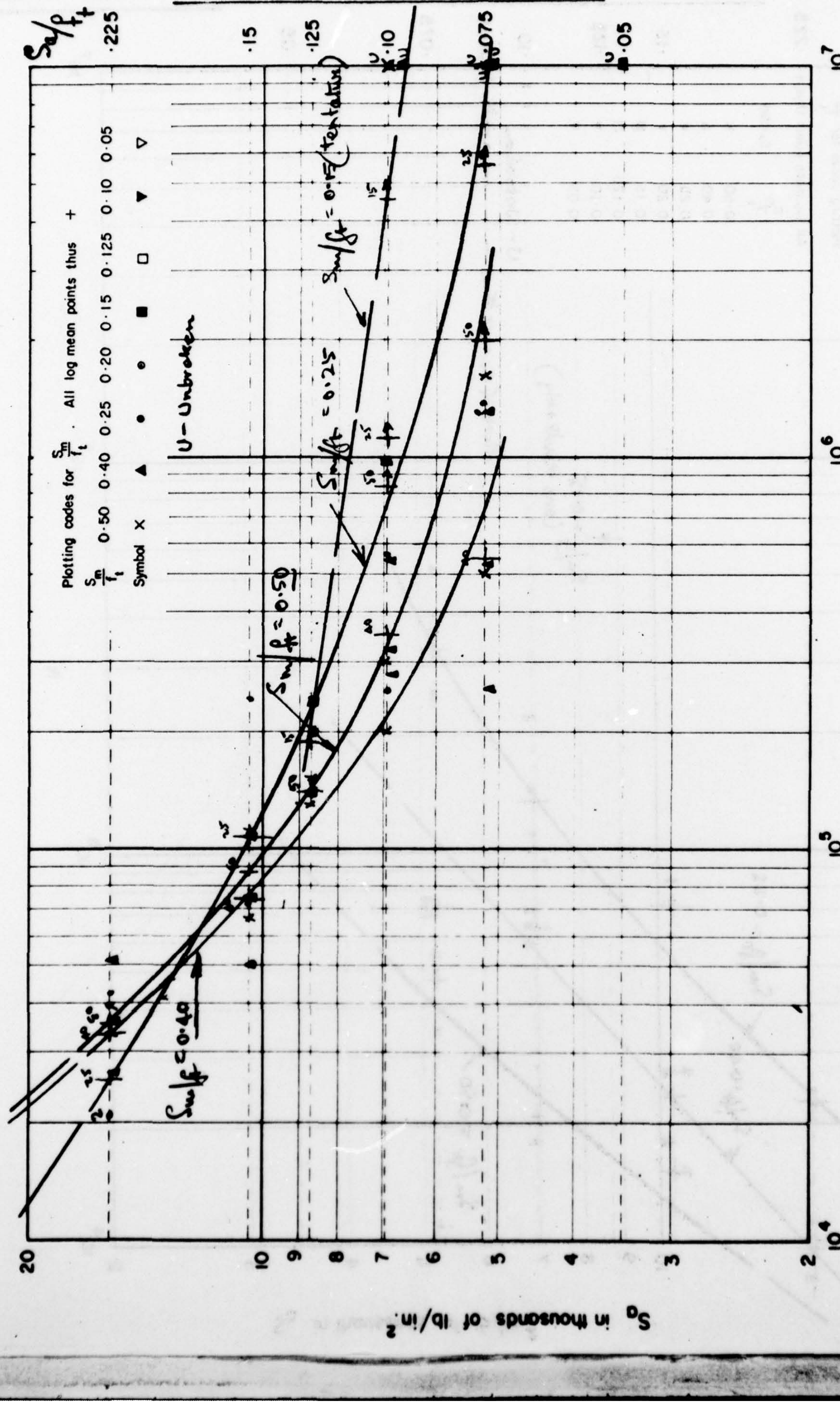


FIG. C.44 SMALL SPECIMENS TYPE 4.C.9/B2 (4/D=2·0) 139

PUSH FIT PIN — PIN UNLOADED

Sm/ft = 0·50, 0·40, 0·25 & 0·15 Ref. TABLE C.44

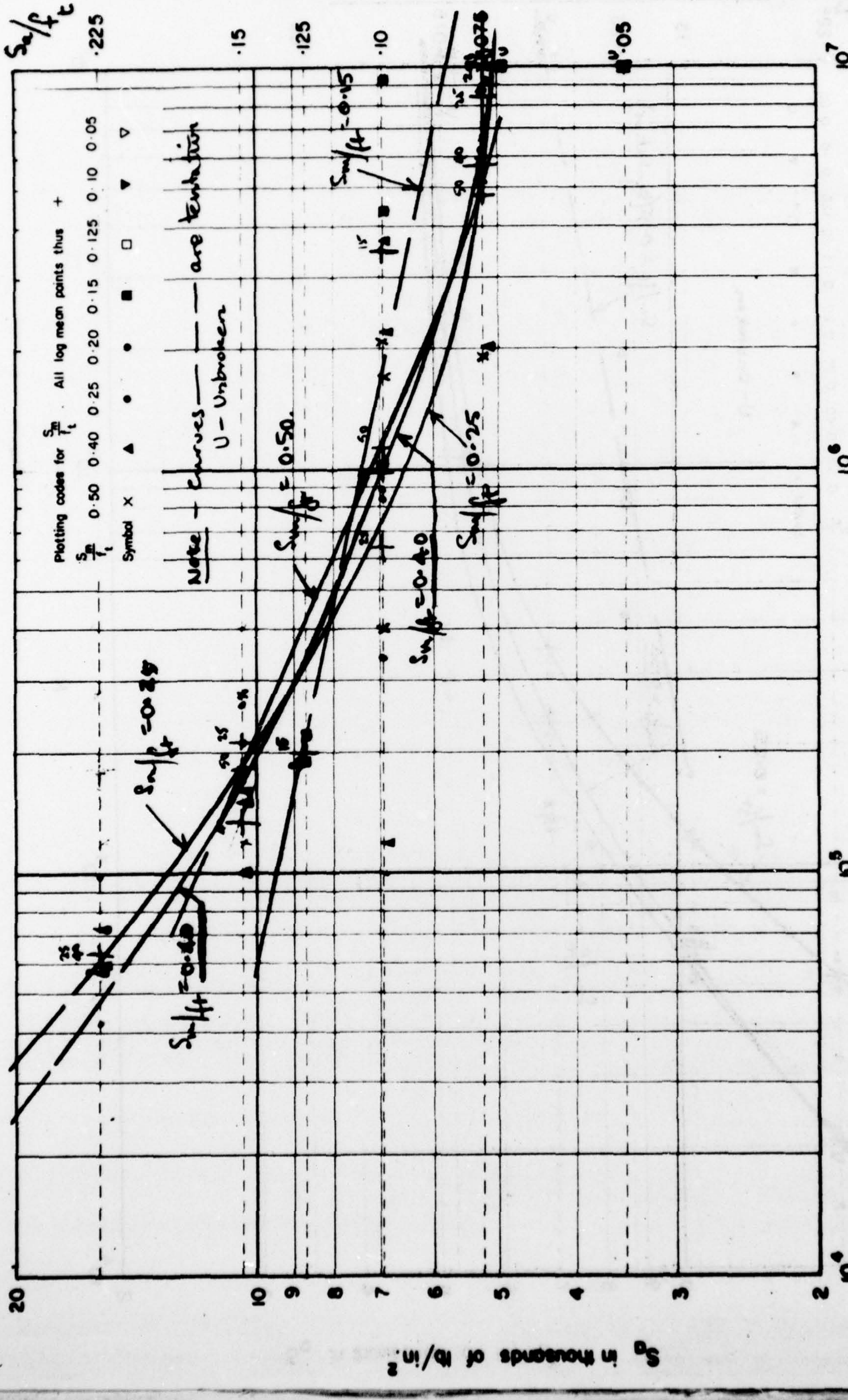


FIG C.15 SMALL SPECIMENS TYPE 4.C.3/8 (a/D = 1/2)

UNFILLED HOLE

Ref: TABLE C.X.48

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

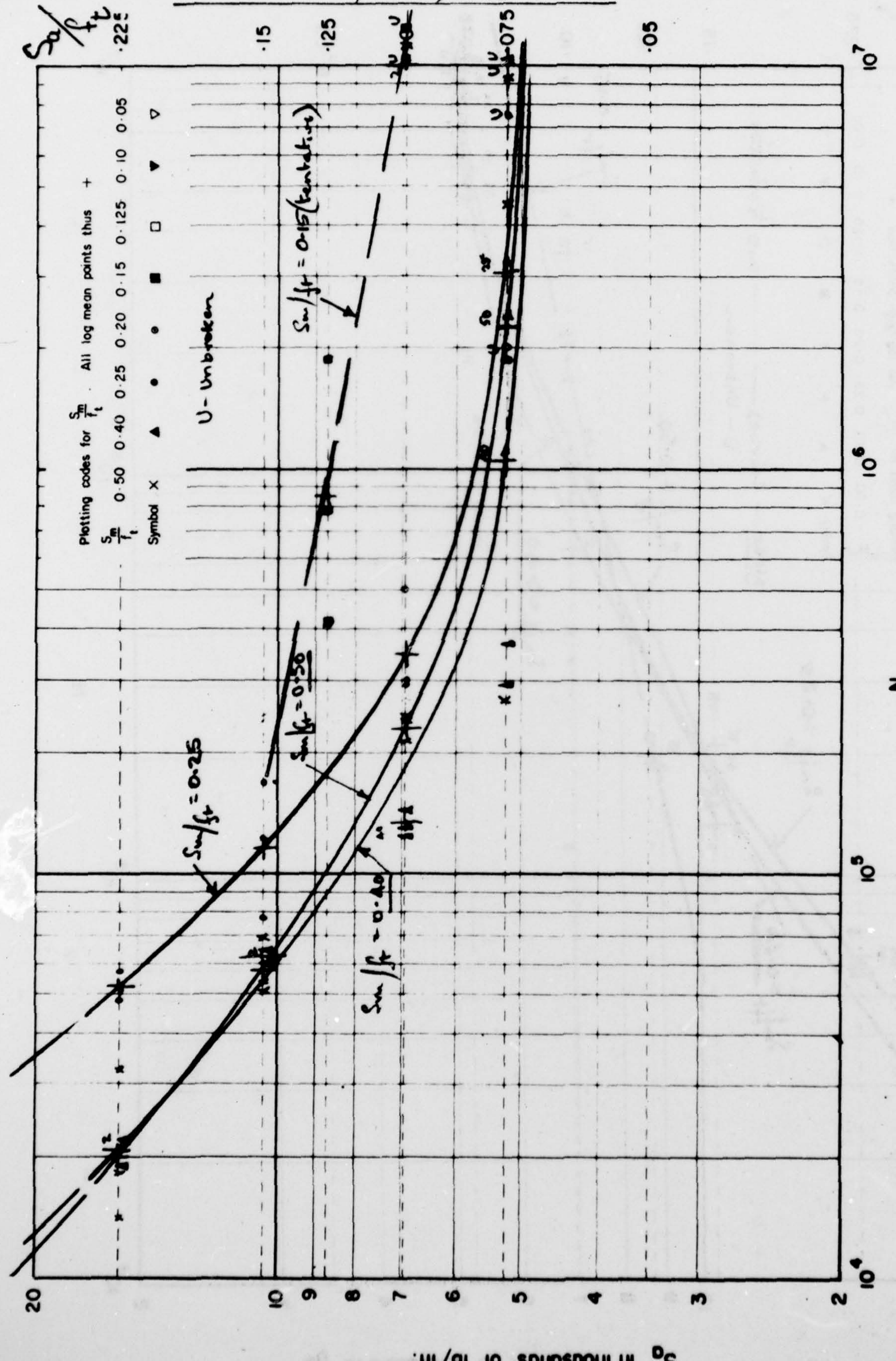


FIG C.46 SMALL SPECIMENS TYPE [illegible]

PUSH FIT PIN — PIN UNLOADED

S_m/f_T = 0.50, 0.40, 0.25 & 0.15 Ref: TABLE C.[illegible]

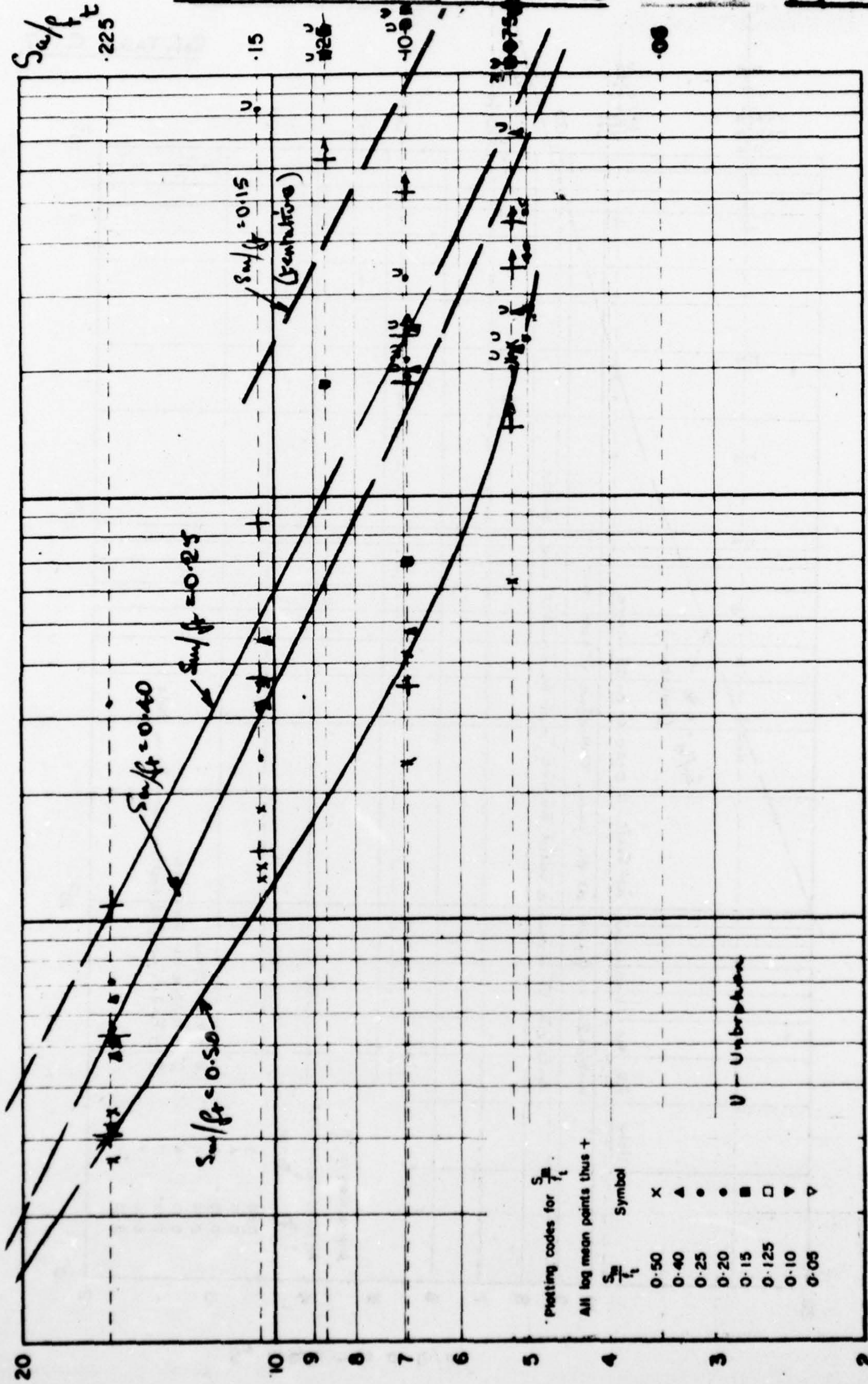


FIG. C.47 SMALL SPECIMENS TYPE 4C 3/8 (d/D = 1/2)

0.4% INTERFERENCE FIT PIN - PIN UNLOADED

S_m/f_t = 0.50, 0.40 & 0.25

Ref. TABLE C.47

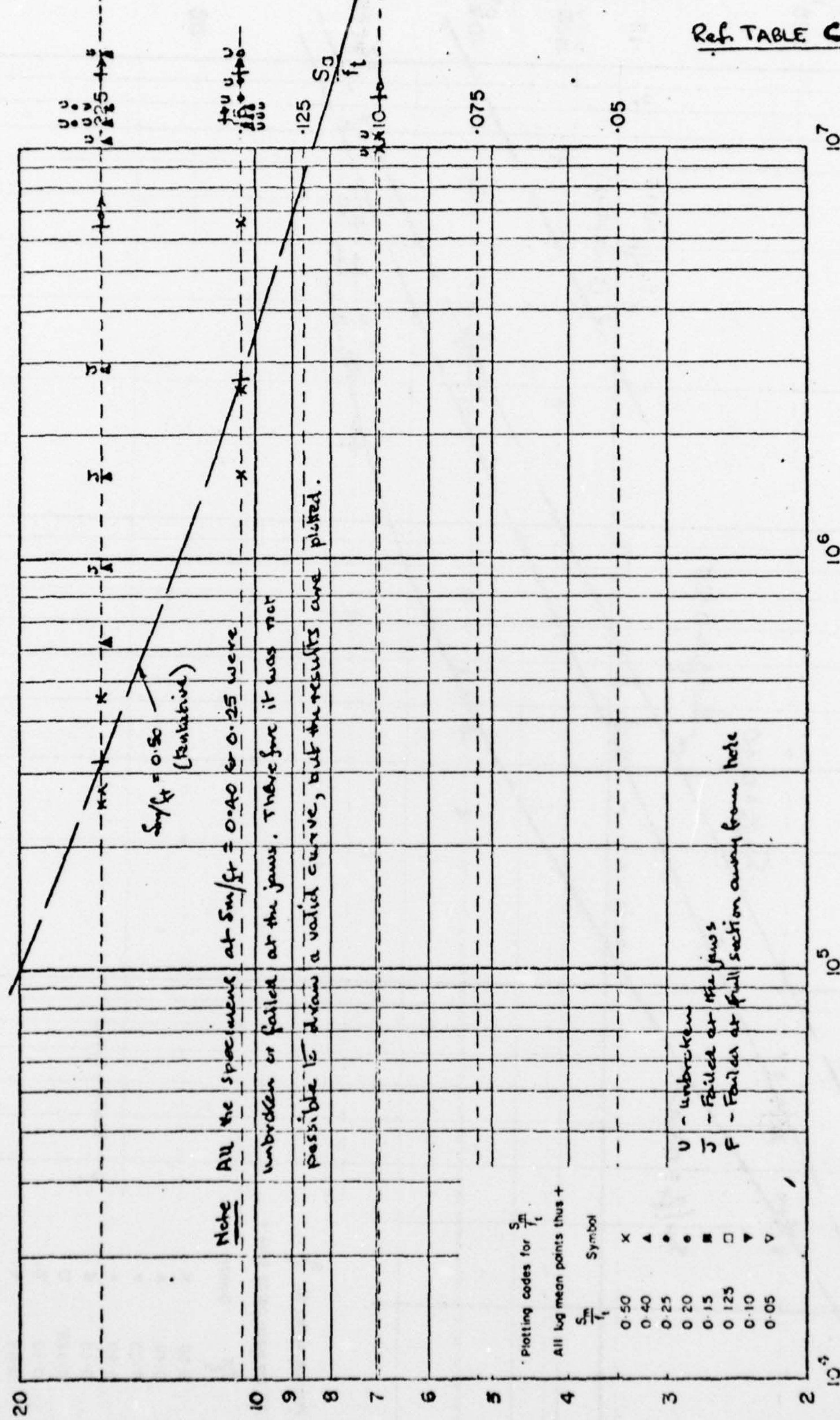


FIG C.48 SMALL SPECIMENS TYPE 4.D.3/8 (a/d = ½) 143

PUSH FIT PIN ~ PIN LOADED Ref: TABLE C.48

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

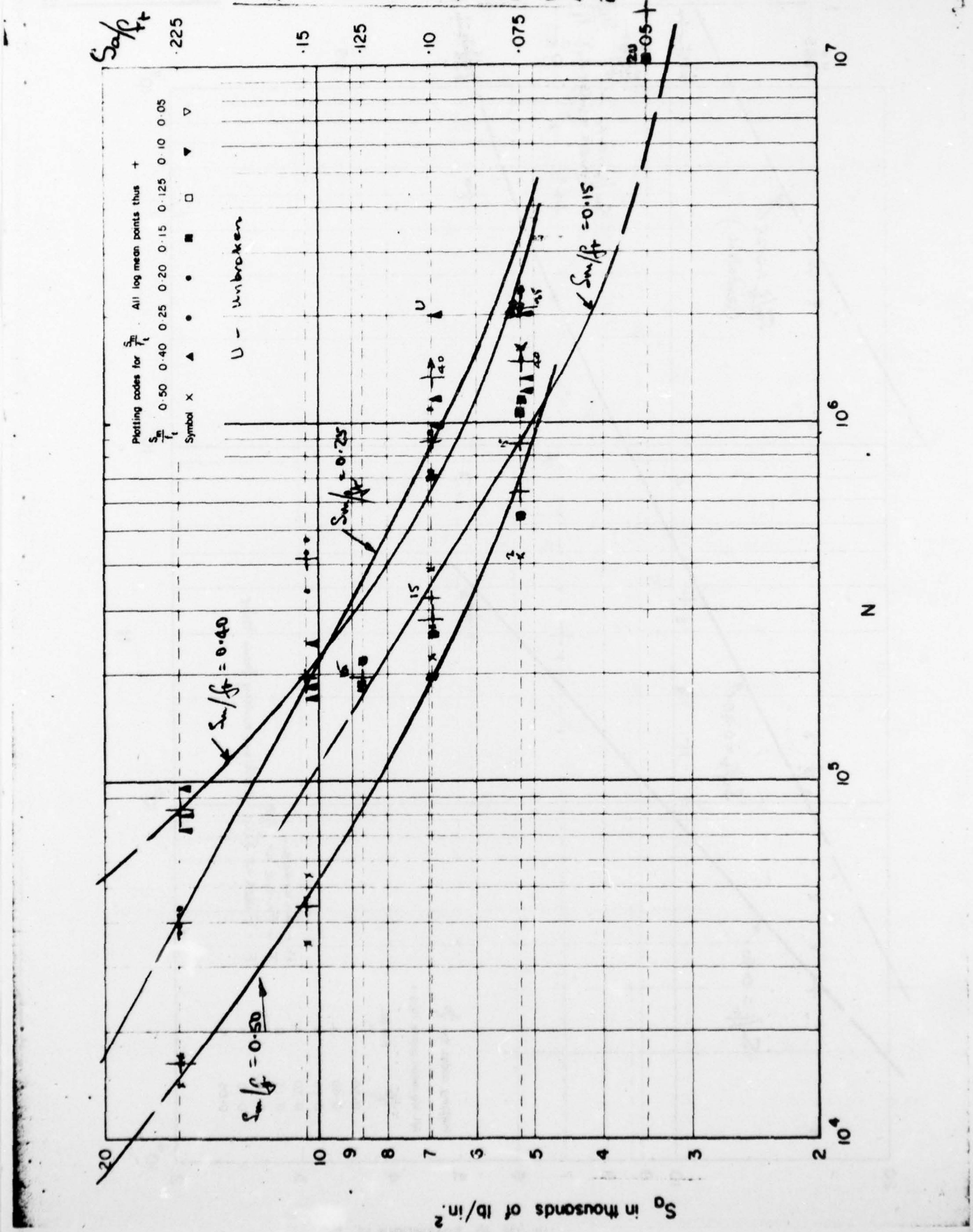


FIG C.49 SMALL SPECIMENS TYPE 4. D.3/8 (H/D = ½)

144 0.4% INTERFERENCE FIT PIN — PIN LOADED

Ref TABLE C.49

S_m/f_t = 0.50, 0.40, 0.25 & 0.15

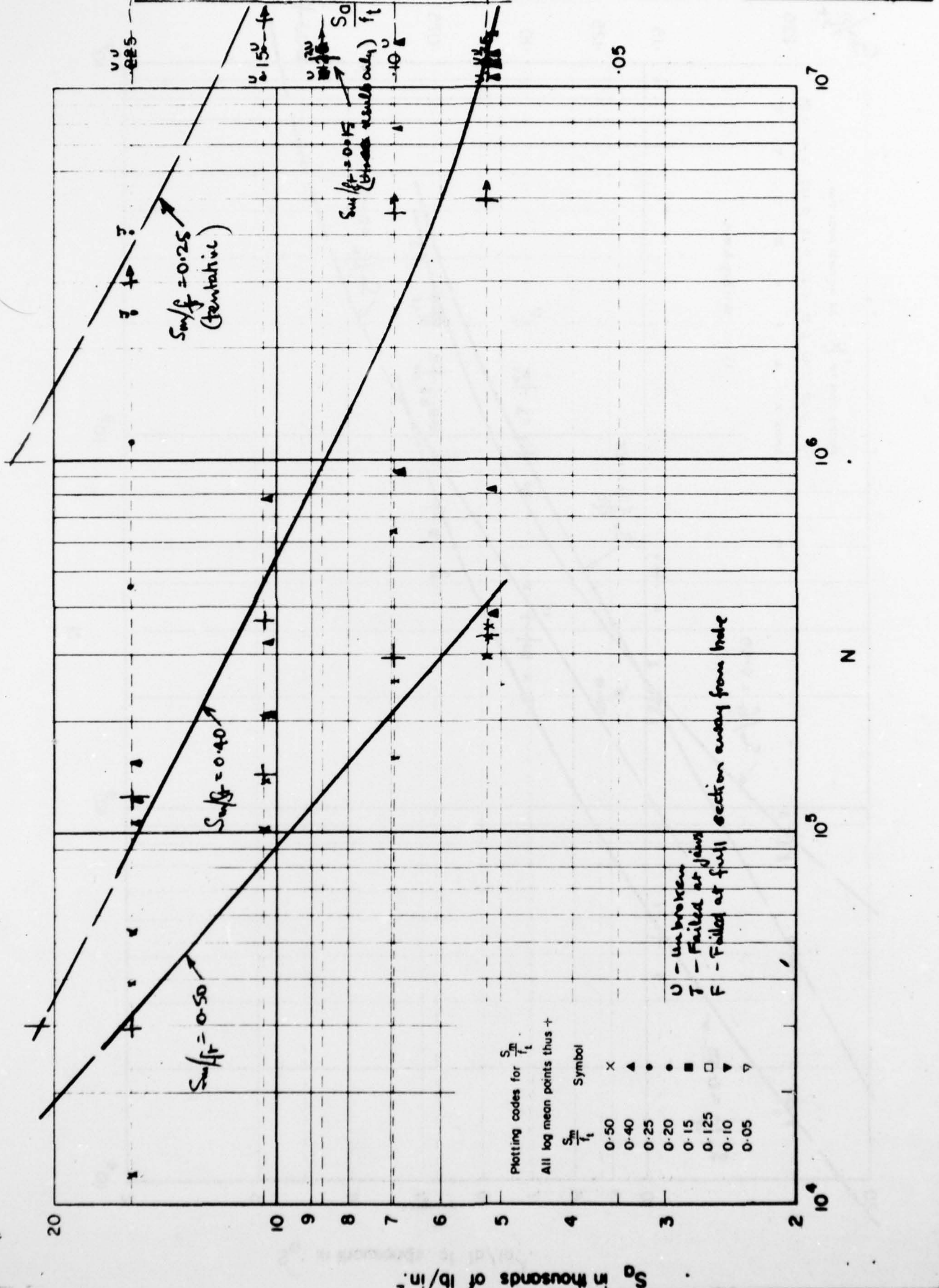


FIG. C.50 SMALL SPECIMENS TYPE A.D. 3/8 ($a/D = \frac{1}{2}$)

0.8% INTERFERENCE FIT PIN – PIN LOADED

145

Ref. TABLE C.50

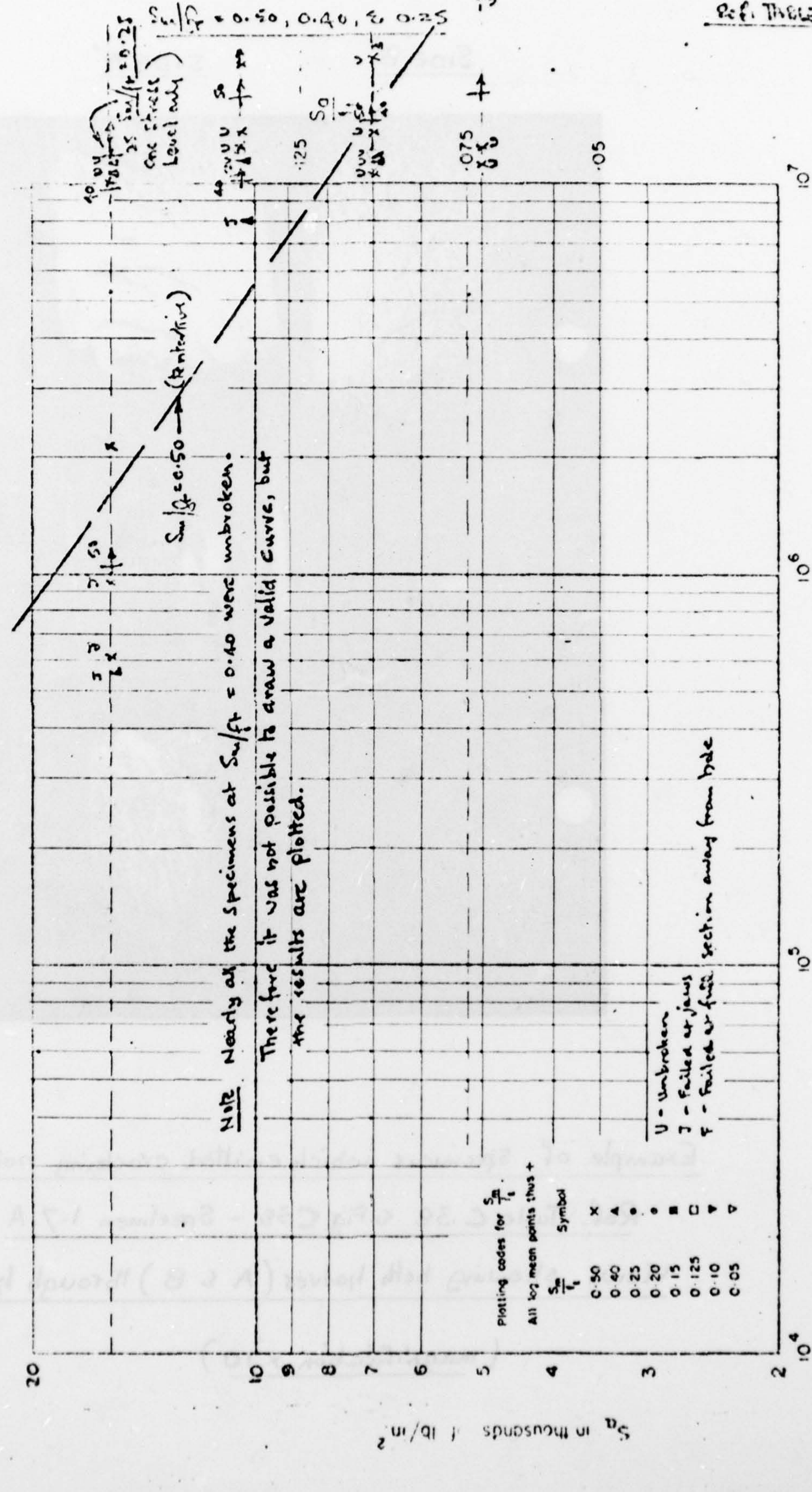
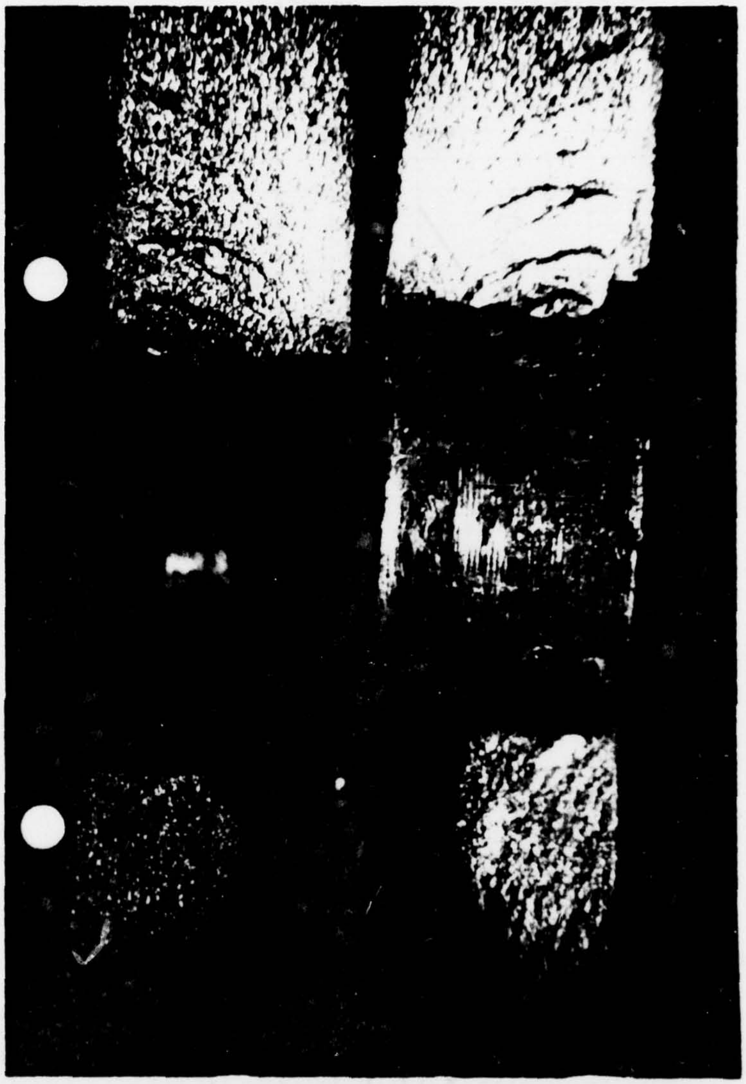


FIG C.51 APPENDIX C

SIDE 'B' SIDE 'A'



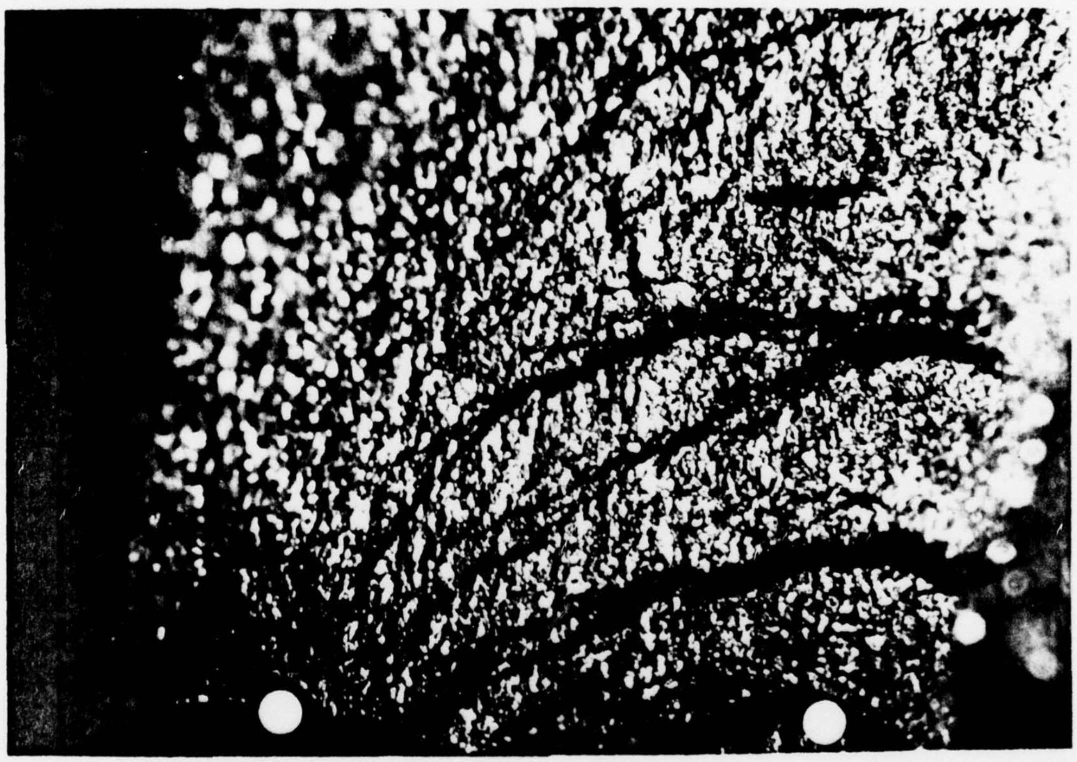
Example of specimens which emitted cracking noises

Ref. Table C.38 & Fig C.38 - Specimen 1.7.A

Views showing both halves (A & B) through hole

(Magnification x 10)

FIG C.52 APPENDIX C



Example of specimens which emitted cracking noises

Ref. Table C.38 & Fig C.38 - Specimen 1.7.A

View of Side 'A' on fatigue surface

(magnification ×40)

REPORT DOCUMENTATION PAGE

(Notes on completion overleaf)

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3134000R	ENGINEERING SCIENCES DATA UNIT, LONDON, UK
5a. Sponsoring Agency's Code (if known)	6a. Sponsoring Agency (Contract Authority) Name and Location
7248000N	PROCUREMENT EXEC., MIN. OF DEFENCE, DR AIR, UK

7. Title

BOLTED JOINT FATIGUE PROGRAMME, VOLUME 2, STAGE 1, APPENDICES A, B AND C

7a. Title in Foreign Language (in the case of translations)

7b. Presented at (for conference papers). Title, place and date of conference

8. Author 1, Surname, initials	9a Author 2	9b Authors 3, 4...	10. Date	pp	ref
Sandifer, R.H.			5.1978	154	-

11. Contract Number	12. Period	13. Project	14. Other References

15. Distribution statement

Descriptors (or keywords)

*Bolted joints, *Fatigue (materials), Aluminium alloys, Fatigue tests, Photoelasticity, Steels, Stress corrosion

Abstract The programme consisted of two major parts - a photoelastic investigation into the stress distribution and resulting stress concentration factors in a family of simple bolted joints, and a correlated series of fatigue tests on bolted metal joints having the same geometrical form as the photoelastic ones using a commonly employed aluminium alloy for the plates and a steel in current use for the pins.

MC

DRIC/76/27

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